SOIL SURVEY

(SEMIDETAILED)

Le Sueur County Minnesota

Series 1944, No. 3

Issued April 1954

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with the
UNIVERSITY OF MINNESOTA AGRICULTURAL EXPERIMENT STATION

How to Use THE SOIL SURVEY REPORT

FARMERS who have worked with their soils for a long time know about soil differences on their own farms, and perhaps about differences among soils on the farms of their immediate neighbors. What they do not know, unless soil surveys have been made, is how nearly their soils are like those on experiment stations or other farms, either in their State or other States, where farmers have gained experience with new or different farming practices or enterprises. Farmers of Le Sueur County can avoid some of the risk and uncertainty involved in trying new crop and soil management practices by using this soil survey report, for it maps and describes the soils in their county and therefore allows them to compare the soils on their farms with soils on which new developments have proved successful.

SOILS OF A PARTICULAR FARM

All the soils in Le Sueur County are shown on the large colored map which accompanies this report. To learn what soils are on a farm (or any tract of land) it is first necessary to locate it on the map. To do this, find the general locality of the farm by using section and township lines, and then use roads, streams, villages, dwellings, and other landmarks to locate the boundaries. Remember that an inch on the map equals half a mile on the ground.

The next step is to identify the soils on the farm. Each area of each kind of soil is shown on the map by a symbol. Suppose, for example, you want to identify an area on the soil map marked with the symbol Cd. Look among the colored rectangles in the margin of the map and find the one with Cd printed on it. Just below this rectangle is the name of the soil—Clarion silt loam, undulating phase. Areas of this soil are marked with this same symbol and have the same color, wherever they appear on the map.

What is Clarion silt loam, undulating phase, like, for what is it used, and to what uses is it suited? For this information turn to the section on Descriptions of the Soils. How productive is this soil? The answer will be found in table 7. In the left-hand column of this table find Clarion silt loam, undulating phase, and read, in columns opposite, the yields of important crops it can be expected to produce. Note the management group number in the last column of this table, and then turn to table 6 to learn what management is considered necessary to get these yields. For information about management, read also in the sections on Descriptions of the Soils and on Water Control on the Land.

SOILS OF THE COUNTY AS A WHOLE

A general idea of the soils of the county is given in the section on Soil Series and Their Relations, which tells about the principal kinds of soils, where they are found, and how they are related to one another. After reading this section, study the soil map and notice how the different kinds of soils tend to be arranged in different parts of the county. These patterns are associated with well-recognized differences in type of farming, land use, and land-use problems.

A newcomer to the county, especially if he considers purchasing a farm, will want to know about the climate; the types and sizes of farms; the principal farm products and how they are marketed; the kinds and conditions of farm tenure; availability of roads, railroads, and electric services; water supplies; industries of the county; and cities, villages, and population characteristics. Information about all these will be found in the sections on General Nature of the Area and on Agriculture.

Those interested in how the soils of the county were formed and how they are related to the great soil groups of the world should read the section on Morphology, Genesis, and Classification of Soils.

This publication on the semidetailed soil survey of Le Sueur County, Minn., is a cooperative contribution from the—

SOIL CONSERVATION SERVICE

and the

UNIVERSITY OF MINNESOTA AGRICULTURAL EXPERIMENT STATION

Series 1944, No. 3 Issued April 1954

SOIL SURVEY (SEMIDETAILED) OF LE SUEUR COUNTY, MINNESOTA

By OLAF C. SOINE and P. R. McMILLER, University of Minnesota Agricultural Experiment Station

Area inspected by I. J. NYGARD, Senior Soil Correlator, Division of Soil Survey,[1] Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, United States Department of Agriculture

United States Department of Agriculture in Cooperation With the University of Minnesota Agricultural Experiment Station

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[1] The Division of Soil Survey was transferred to the Soil Conservation Service on November 15, 1952.

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THE FIRST settlers arrived in Le Sueur County in 1851. They began clearing the land of hardwood forest, and, as transportation developed, wheat became their important crop. About 1900, severe epidemics of rust made wheat unprofitable and forced a change to general farming and dairying. Now, livestock raising, dairying, and growing of canning crops are the leading sources of income. The field crops grown are mainly those needed for feeding livestock. The majority of the farmers use methods of management well suited to the type of agriculture, but few are using erosion control practices. Some of the steeply sloping land is losing much surface soil through erosion. Most of the soils are well supplied with organic matter, lime, and plant nutrients but will produce larger yields, particularly of corn, if complete commercial fertilizer is applied. To aid farmers in determining the best agricultural uses for their land, the United States Department of Agriculture and the University of Minnesota Agricultural Experiment Station made a cooperative soil survey of Le Sueur County. This report sets forth the findings of the survey, which was completed in 1944. Unless otherwise specifically mentioned, statements in this report pertain to conditions in the county at the time the survey was completed.

GENERAL NATURE OF THE AREA

LOCATION AND EXTENT

Le Sueur County is in the south-central part of Minnesota (fig. 1). Le Center, the county seat, is 50 miles southwest of St. Paul, the State capital, and 65 miles northwest of Rochester. The county has a total area of approximately 441 square miles, or 282,240 acres. About 28 square miles is covered by water.

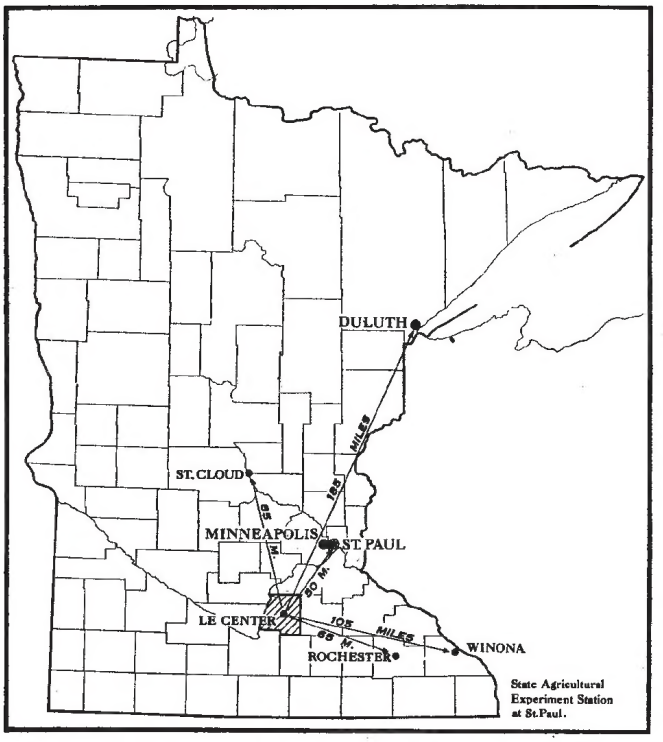

FIGURE 1.—Location of Le Sueur County in Minnesota.

PHYSIOGRAPHY, RELIEF, AND DRAINAGE

Le Sueur County lies in the Central Lowland province of the Interior Plains. It is in an area where several ice invasions advanced and retreated during the glacial period. The most recent glacier—the Mankato stage of Late Wisconsin glaciation—deposited a yellowish-gray limy moderately heavy textured material of variable thickness. On the upland above the terraces this deposit is probably more than 100 feet thick.

In the eastern and southern parts of the county are terminal moraines where the land surface is sharply rolling and even hilly in some places. Near many lakes in the southern part of the county the glacial till is not so heavy and is sandier than on the smoother areas, for it has been modified during deposition by waters from the melting glaciers. Small areas of stratified sand and gravel are associated with the heavier material.

Along the Minnesota River is a flood plain ranging from ⅛ to 2 miles wide. Above this plain are two well-defined terraces that rise rather abruptly about 75 feet above the river. One, about 2 miles wide, extends south from Kasota to beyond the county line. It is a structural bench of Jordan sandstone capped with Shakopee limestone on which there is a thin layer of soil. The terrace near Le Sueur, from 3 to 4 miles wide, is of similar origin but has a deeper covering of soil material.

Jordan sandstone and Shakopee limestone, members of the Lower "Magnesian" or "Calciferous" formations, are the only exposures of native bedrock in the county. They occur near the villages of Kasota and Ottawa and in other places along the bluffs adjacent to the Minnesota River. The Shakopee formation is a hard buff-colored dolomite that was originally 50 to 75 feet thick. Erosion, however, has removed a large part of it, leaving some 10 to 15 feet. Underlying the Shakopee dolomite is the white or gray iron-stained fine- to coarse-textured Jordan sandstone, which ranges from 25 to 75 feet in depth.

The relief of the county is characteristic of that of a glaciated area. It ranges from nearly level or gently rolling in the till plain area to strongly rolling in the morainic belt. The elevation of the till plain ranges from 940 to 1,020 feet, and that of the morainic area from 975 to 1,050 feet. The morainic hills are from 50 to 75 feet above the adjoining smoother plains. Many slopes are short and steep, and the intervening depressions are occupied by small lakes, marshes, and peat bogs. The smoother till plain outside the morainic area is some 275 to 300 feet above the level of the Minnesota River.

The Minnesota River has a drop of about 24 feet in its course along the western border of the county. The elevation of Montgomery is 1,063 feet; Kilkenny, 1,057; Waterville, 1,007; New Prague, 941; Kasota, 804; and Le Sueur, 760. The highest point is in the hills south of Sakatah Lake.

The Minnesota River, flowing northward along the western boundary, drains about three-fourths of the county. Its principal tributaries are Chanceska, Cherry, Le Sueur, and Forest Prairie Creeks. Drainage in the southeastern part is eastward into the Mississippi River through the Big and Little Cannon Rivers, flowing through Tetonka and Sakatah Lakes. In the rolling areas runoff is rapid and some soil is removed and deposited on the lower lands or carried away by the streams. Many bottom land soils are flooded, especially during the spring thaw.

CLIMATE

The county has a midcontinental type of climate, characterized by seasonal variations in temperature, low winter precipitation, and generally abundant summer rainfall. The climatic data given in table 1, compiled from records of the United States Weather Bureau at St. Peter, are considered representative for Le Sueur County. St. Peter is just outside of Le Sueur County, or on the opposite side of the Minnesota River, in Nicollet County.

Most of the precipitation falls during the growing season, or from May through September. Rainfall is highest in June. During the growing season thunderstorms frequently occur. Normally, one or more storms damage growing crops and erode the soil. Tornadoes and hailstorms are rare and not regarded as a serious hazard to farming, though they sometimes damage buildings and destroy crops.

The average January temperature is 14.7° F., and that for July, the warmest month, 73.0°. The maximum temperature recorded was 106°, and the minimum, −40° F. The growing season averages 143 days, or from May 9 to September 29. The latest spring frost recorded was on June 22, and the earliest in fall, on September 10.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at St. Peter, Nicollet County, Minn.*

[Elevation, 825 feet]

Month	Temperature [1]			Precipitation [2]			
	Average	Absolute maximum	Absolute minimum	Average	Total for the driest year	Total for the wettest year	Average snowfall
	° *F.*	° *F.*	° *F.*	*Inches*	*Inches*	*Inches*	*Inches*
December	20. 2	60	−30	0. 85	2. 06	0. 98	5. 6
January	14. 7	52	−40	. 88	. 90	. 74	8. 2
February	17. 7	68	−36	. 70	. 48	1. 26	5. 4
Winter	17. 5	68	−40	2. 43	3. 44	2. 98	19. 2
March	31. 7	84	−20	1. 27	1. 03	. 72	6. 3
April	47. 2	92	−5	2. 21	1. 14	3. 22	1. 8
May	58. 7	98	21	3. 32	1. 48	9. 06	[3]
Spring	45. 9	98	−20	6. 80	3. 65	13. 00	8. 1
June	68. 3	102	33	4. 71	2. 95	12. 10	0
July	73. 0	106	34	3. 40	2. 33	6. 82	0
August	70. 8	104	35	3. 46	2. 24	1. 03	0
Summer	70. 7	106	33	11. 57	7. 52	19. 95	0
September	62. 6	103	24	3. 42	. 54	1. 11	0
October	50. 2	90	4	2. 19	. 12	2. 40	. 5
November	33. 9	77	−22	1. 29	1. 28	. 93	2. 7
Fall	48. 9	103	−22	6. 90	1. 94	4. 44	3. 2
Year	45. 8	106	−40	27. 70	[4] 16. 55	[5] 40. 37	30. 5

[1] Average temperature based on 57-year record, 1894 to 1950; highest and lowest temperatures from 37-year record, 1894 to 1930.

[2] Average precipitation based on 62-year record, 1889 to 1950; wettest and driest years based on 64-year record, 1887 to 1950 inclusive but for 1892; snowfall on 37-year record, 1894 to 1930.

[3] Trace.

[4] In 1889.

[5] In 1908.

The climate is well suited to all the principal farm crops grown in this part of the State. For hybrid corn the county is in the zone where varieties requiring from 110 to 116 days for maturity are recommended.[2] The growing season is also long enough for production of such small grains as oats, barley, and flax.

The new varieties of oats ripen before the hot midsummer weather begins and yield well. Recently some of these varieties have been affected by serious diseases that have curtailed yields. Legumes and

[2] HAYES, H. K., MURPHY, R. P., RINKE, E. H., and BORGESON, C. MINHYBRID CORN VARIETIES FOR MINNESOTA. Univ. Minn. Agr. Expt. Sta. Bul. 354, 40 pp., illus. 1941.

winter grains occasionally winterkill; probably this is caused partly by lack of a protective snow cover. Midwinter freezing and thawing often break the roots of the legumes from the crowns and thus injure the stand. Peat bogs are commonly subject to early and late frosts and therefore are generally seeded to tame grasses rather than to grain or other crops. The crops on the sandy terraces are often affected by summer drought, for the soils in those places have a low water-holding capacity. In the more level areas on the uplands, where heavier soils predominate, drainage becomes an important factor in crop production, especially in years with more than normal rainfall.

WATER SUPPLY

During early settlement, the Minnesota River was an important means of transportation and a source of power. In 1869, when the first railroad joined Mankato with the Twin Cities, all water transportation ended between these cities and intermediate points on the Minnesota River. Between 1870 and 1880 there were four water power stations in the county that furnished power for grinding wheat. Now, no water power is developed in the county.

All the water for human consumption is obtained from wells, most of which are 100 feet or more deep. A few springs provide water for livestock. Most farms are equipped with pumps driven by a windmill or gasoline engine, but as electrical service becomes available throughout the rural districts electrically driven pumps gradually replace the old types. Many of the small streams, depressions, and peat bogs furnish water for the livestock during the grazing period.

In the hilly part of the county many tree-fringed lakes afford recreational opportunities. Most of the larger and deeper ones—Sakatah, Tetonka, Francis, Washington, Jefferson, and German—are in the southern part of the county. Many summer cottages border the shores, and fishing is usually good. The smaller shallow lakes and the marshes are sanctuaries for game birds.

VEGETATION

The county lies within the southern part of the Big Woods area. Before settlement began most of the county was covered with a hardwood forest of basswood, sugar maple, soft maple, boxelder, white and black ash, white or American elm, butternut, black walnut, black and bur oaks, ironwood, aspen, cottonwood, cherry, and some redcedar. Some of the common shrubs were prickly-ash, sumac, Virginia creeper, climbing bittersweet, honeysuckle, elder, hazelnut, and willow. Many wild berries, as raspberry, chokecherry, gooseberry, black currant, and highbush cranberry, also thrived. A few areas were devoid of trees; one was the Le Sueur Prairie, and another, the limestone terrace around Kasota.

Tracts of the original forest remain in all parts of the county, and many are used for woodland pastures. Much of the land in the rolling belt in the eastern and southern parts of the county, especially around the lakes, is forested.

WILDLIFE

Before the first settlers moved into the county deer, bear, raccoon, wild turkey, prairie chicken, grouse, partridge, ducks, and geese in-

habited the region. As the land was cleared for crops the game gradually disappeared. Now the wildlife is limited to ducks and other migratory birds, pheasants, a few quail, and gray squirrels. Several small game refuges have been established, one of about 1,000 acres is near Montgomery, a somewhat larger one is north of Waterville, and a smaller one is along the Minnesota River near Kasota. Many individual farms are themselves game refuges. These farm refuges are usually sponsored by members of local 4–H Clubs.

ORGANIZATION AND POPULATION[3]

Le Sueur County was named after the early French explorer, Charles Pierre Le Sueur. About 1700, Le Sueur journeyed up the Mississippi River from New Orleans to explore the territory in the upper Mississippi Valley. His travels took him up the Minnesota River to a point where the Blue Earth River joins it, not far from Mankato.

The first permanent settlement was made in 1851. In 1855 about 18 families from Vermont migrated to the county and formed a settlement about 2 miles east of the town of Le Center. Other Vermont families settled in Lexington Township in the central part of the county. In 1856 Czech settlers from the neighboring States of Iowa, Illinois, and Wisconsin moved near New Prague. The settlers supplemented their livelihood with fishing, hunting, and the gathering of wild ginseng. The nearest river towns, some 12 to 15 miles away, were the principal source of supplies and the outlets for the products the settlers had to sell. In preparing the wooded land for cropping, groups of farmers with their oxen went to one farm and had a clearing bee. In many places the stumps were left in the fields until they partly decayed. After the decay, they could be removed more easily.

Census reports for 1950 list the total population of the county at 19,088. The rural population is fairly evenly distributed, though areas with dark heavier textured soils support a somewhat greater population than the areas with soils less desirable. Le Sueur, the largest city in the county, had 2,713 inhabitants in 1950. Montgomery, New Prague, Waterville, and Le Center are other population centers in the county.

INDUSTRIES

The basic occupation of the county is agriculture. No large industries compete with agriculture for labor, and only during peak periods, such as harvesttime, are farm laborers hired by the day. Food processing plants and retail establishments employ many people. Vegetable canneries are located at Le Sueur and Montgomery.

TRANSPORTATION AND MARKETS

Prior to the entry of the railroad in 1869, the early settlers used the streams, particularly the Minnesota River, as a means of transportation. Four railroads now serve the county. The Chicago and North Western Railway follows the Minnesota River along the western side of the county. The Minneapolis and St. Louis Railroad crosses the eastern side, the Chicago, Milwaukee, St. Paul and Pacific Railroad

[3] Information from letters, papers, and diaries in the collection of the Minnesota Historical Society, St. Paul.

traverses the county from southwest to northeast, and the Chicago Great Western Railway crosses the most southerly part. Four State highways cross the county, and U. S. Highway No. 169 runs through the western part. The entire system of State and Federal roads is well maintained throughout the year, and most county roads are graded and graveled.

Nearly all the livestock is transported by truck to the markets at South St. Paul and Austin. Milk and cream are collected daily and transported to local creameries and distributing centers.

FARM AND COMMUNITY IMPROVEMENTS

In the more level areas where well-drained dark heavy soils predominate, the farmsteads are somewhat better maintained than in areas where the soils are imperfectly drained (pl. 1). The townships in the well-drained areas support a larger farm population, which has a somewhat better standard of living. Nearly all the farm homes have access to telephone service. Census reports for 1950 list 1,071 farms with telephones. The Rural Electrification Administration is making electricity available to all rural areas. Many farms have their buildings wired for electricity that is used for both light and power. The 1950 census reported 1,826 farms with electricity.

Rural grade schools are well distributed over the county, and school busses provide transportation. Churches are conveniently located in various parts of the county. Rural mail service reaches all parts of the county.

AGRICULTURE

EARLY AGRICULTURE

Little is known about the Indians who inhabited this region, but their agriculture must have been primitive. Various tribes roamed the area. They made temporary homes along the Minnesota River and some of the lakes where hunting and fishing were good.

The early settlers removed the trees, prepared seedbeds, and planted corn among the stumps. The mature corn was made into hominy or fed to livestock. The settlers substantially increased their income by gathering and selling wild ginseng and cranberries.

As more land was cleared and prepared for cultivation, wheat became an important crop. In the early years of farming wheat and corn were planted and harvested by hand. Some of the wheat was taken to local gristmills and ground into flour for home use, and the rest was hauled to towns along the Minnesota River for shipment by boat to distant markets. As the rural population increased, more land was cleared and seeded to wheat. Invention of the reaper and other labor-saving machinery encouraged further increases in wheat acreage. About 1900, severe rust epidemics resulted in decreased yields, and thereafter wheat production declined. The trend of agriculture therefore has been first to forest products, then to cereal crops, and finally to livestock raising and dairying—the type of farming that now prevails.

Well-kept farmstead on Lester soil, typifying the prosperous condition of many of

A, Field of oats on Burnsville sandy loam, rolling phase.
B, Improved farm on Clarion silt loam, undulating phase.
C, Corn growing on Hayden silt loam and loam, rolling phases.

CROPS

The acreages of principal farm crops in Le Sueur County are given in table 2 for stated years. The shifts in acreages indicate the general trend of agriculture in the county. Acreages of corn and oats have increased since 1919, whereas acreages of wheat have decreased.

TABLE 2.—*Acreage of the principal crops and number of fruit trees and grapevines of bearing age in Le Sueur County, Minn., in stated years*

Crop	1919	1929	1939	1949
Corn:	*Acres*	*Acres*	*Acres*	*Acres*
For grain	38,073	41,906	47,549	59,749
For silage and forage	10,524	9,662	4,183	6,419
Small grains threshed or combined:				
Oats	9,353	14,294	23,257	40,389
Wheat	65,711	13,651	14,305	7,299
Barley	1,550	23,653	11,163	4,764
Rye	1,635	1,203	525	580
Flaxseed	18	114	2,545	5,643
Soybeans harvested for beans	(1)	(1)	76	5,283
All hay	32,674	34,847	35,979	29,821
Alfalfa	342	5,937	10,860	9,967
Clover and timothy, alone or mixed	7,205	5,068	4,175	2,507
Other legumes cut for hay	55	10	325	99
Small-grain hay	96	23	404	354
Other tame hay	7,447	4,638	6,041	3,166
Wild hay	17,529	19,171	14,174	13,728
Potatoes	1,331	736	609	[2] 109
Sugar beets	157	93	144	286
Canning crops:				
Sweet corn	(1)	3,066	3,227	4,759
Peas	(1)	2,602	2,036	2,465
	Number	*Number*	*Number*	*Number*
Apple trees	29,663	20,683	6,566	7,496
Plum and prune do	1,394	3,537	2,452	2,279
Maples tapped do	7,371	(1)	1,524	(1)
Cherry do	216	287	78	135
Grapevines	568	1,230	583	840

[1] Not reported.
[2] Does not include acreages for farms with less than 15 bushels harvested.

CORN

Corn for grain is planted from May 10 to May 20. Most of it is planted in rows, and the hills are evenly spaced to permit cross cultivation. Corn for silage is usually drilled in a week or so later than corn for grain and is ready to put into the silo early in September. Corn to be cribbed is left in the field until frosts have killed the plants, thus hastening drying of the grain. Most of the corn is machine-picked.

SMALL GRAINS

The large increase in acreage of oats results partly from the introduction of new higher yielding varieties. Oats fit well into a satisfactory crop rotation. Both spring and winter varieties of wheat are

grown. Some of the wheat is sold to the local elevators and milling concerns within and outside the county, but much is fed to livestock. The acreage in barley has decreased greatly since 1929. Rye and flax are also grown.

HAY

Both tame and wild hay are grown on a considerable acreage. The acreage in alfalfa has increased greatly since 1919, whereas that of clover and timothy has decreased. Alfalfa is normally harvested two or three times a year; the first cutting is made after the middle of June. Clover, timothy, small-grain hay, and annual legumes are grown. Soybeans were the only annual legume cut for hay in 1949. The comparatively large acreage of wild hay is harvested from the large number of small peat bogs and poorly drained areas scattered over the county. Most of the farms are comparatively small and have some undrained land, so the farmer depends on wild hay for part of his forage. Wild-grass hay is cut later than alfalfa, usually when time is available between other farm operations. In wet years wild hay is often cut late in summer, but it is then overmature and has lost some of its nutritive value. Some of the wetter peat areas have been drained and seeded to reed canarygrass, which does well in areas that are not excessively wet the year around.

CASH CROPS

Canning crops, especially peas and sweet corn, are important sources of cash income, though the acreage planted to them is comparatively small. Canning crops are sold under contract to the canneries in Le Sueur and Montgomery.

MANAGEMENT PRACTICES

Most farmers practice good cultural methods. The majority of them have tractors with ample equipment. A few depend on horsepower alone, but many combine animal and tractor power in farming operations.

Fall plowing of the heavy soils is the usual practice for fields to be sown to small grains and corn. A good seedbed is prepared in spring as soon as the land is dry enough to work. The small grain is sown in mid-April or later in the month. The grain usually ripens late in July or early in August and is usually harvested with tractor-driven binders or small combines. Threshing rings—groups of five or six neighboring farmers who own a threshing machine together—move from farm to farm as the season advances.

Since sale of livestock and livestock products provides the principal income for farmers of this county, a system of management that provides ample supplies of feed concentrates, forage, and pasture must be followed. Nearly all the crops produced in the county are used for livestock feed; only some concentrates for hogs and poultry must be imported. In summer good pasture is available, and this helps reduce feed costs.

Most crop rotations keep the land in corn and grain; hay or sod crops are on the soils little of the time. A 5-year rotation in common use consists of corn, small grain, corn, small grain seeded with a grass-and-legume mixture, and hay. On farms with a considerable acreage of peat, all the tillable land is usually cropped, and a 2-year rotation

(corn and small grain with an occasional hay crop) is followed. The peat on these farms has often been seeded to tame grasses and is depended on for nearly all the hay and pasture.

On farms where less land is available for wild hay, more tame hay and pasture crops are included in the rotation. The usual rotation then consists of corn, small grain seeded with clover and timothy, and hay. Frequently alfalfa and bromegrass are seeded with the grain and left for 2 years or more.

Most of the soils contain enough lime for sweetclover and alfalfa, the crops most sensitive to a lack of lime. Barnyard manure is used. Most of it is applied to the cornland in fall or early in spring prior to planting. Most of the farmers use little commercial fertilizer, though the commercial concerns, such as growers of hybrid seed corn and canning crops, use liberal quantities.

PERMANENT PASTURE

Nearly every farm has some nontillable land in permanent pasture. Peat land, bottom land along the streams subject to flooding, steep often stony land adjoining streams, and other land unsuited to cultivation is used for permanent pasture. Some of the peat bogs have been tile drained and seeded with a mixture of reed canarygrass, redtop, and timothy. In 1949, 72,200 acres was in pasture. Of this, 5,879 acres was cropland pastured; 27,715 acres, woodland pastured; and 38,606 acres, other land pastured.

The acreage in pasture is least on the dark heavy-textured soils in Tyrone and Sharon Townships, for these soils are practically all suited to tilled crops. The acreage of permanent pasture is largest in the eastern and southern parts of the county, where the relief is more rolling, peat bogs are more numerous, and wooded areas are more prevalent. On the Minnesota River bottom where overflows are frequent, about 50 percent of the acreage is in permanent pasture. Most of the land occupying the broad terrace in the vicinity of Kasota and south to the county line is also in permanent pasture because the numerous sandstone and limestone outcrops and the shallowness of the soil prevent crop growth.

The stand in the permanent pastures consists chiefly of bluegrass, volunteer white clover, and various wild grasses. Little attention is given to pasture improvement. In July and August, usually the hottest months, the bluegrass remains more or less dormant and the pastures provide little forage. During this period some of the farmers use supplementary pasture crops such as Sudan grass, sweetclover, and even new stands of alfalfa.

The general trend in acreage of permanent pasture has been upward. In the eastern and southern parts of the county, the increase in acreage has been more pronounced. Some of the wooded pasture in those areas has been converted to cropland, but a larger proportion, consisting of eroded sloping areas formerly in crops, has reverted to permanent pasture. In the level areas occupied by heavy-textured soils, as for example in parts of Cordova and Lexington Townships, some of the land provided with drain tile is being used for permanent pasture because the drainage system does not function satisfactorily. In other areas where better land has been improved by tile drainage, a corresponding or larger acreage of poorer land has reverted to permanent pasture.

LIVESTOCK

The numbers of livestock in the county are given in table 3 for stated years.

TABLE 3.—*Principal livestock on farms in Le Sueur County, Minn., in stated years*

Livestock	1920	1930	1940	1950
	Number	*Number*	*Number*	*Number*
Horses	10, 087	9, 075	[1] 8, 082	3, 637
Cattle	32, 952	34, 680	[1] 33, 213	32, 554
Dairy	20, 407	[2] 20, 121	[2] 18, 779	[3]
Beef	12, 545	[2] 1, 582	[2] 1, 487	[3]
Swine	34, 117	60, 113	[4] 30, 612	54, 794
Sheep	2, 943	5, 275	[5] 6, 493	5, 526
Chickens	184, 033	[1] 224, 958	[4] 203, 928	[4] 307, 619

[1] Over 3 months old, Apr. 1.
[2] Over 2 years old.
[3] Not reported.
[4] Over 4 months old, Apr. 1.
[5] Over 6 months old, Apr. 1.

The increased use of tractors and trucks is reflected by a decrease in the number of horses and mules. Percheron and Belgian are the most popular breeds of horses. Only 15 mules were reported on farms in 1950. The expansion of the dairy industry has been largely responsible for the decline in number of beef cattle. Every year a comparatively large number of feeders are brought into the county to be fattened and sold later.

The milk cows are predominantly Holstein-Friesian, followed by Guernsey, milking Shorthorn, and Brown Swiss. According to the Minnesota Department of Agriculture, eight creameries in the county produced 1,760,310 pounds of butter in 1945.

Hogs are raised on nearly every farm. The two principal breeds are Chester White and Duroc. Almost every farm has a small flock of chickens. A few farms derive considerable income from the sale of poultry and poultry products.

TYPES OF FARMS

Census releases for 1950 list 2,006 farms in Le Sueur County. The average size of the farms was 139.1 acres. Clearing of forested areas and reclaiming of some poorly drained land by tile drainage have increased the acreage of tillable land.

According to type, the farms are classified as follows: 615 livestock (mixed), 748 general, 246 dairy, 80 poultry, 151 field crop, 2 vegetable, and 164 miscellaneous or unclassified.

FARM TENURE

Census releases for 1950 report that 1,653 farms in Le Sueur County were operated by owners, 348 by tenants, and 5 by managers. About half the tenants rent on a cash basis. In livestock and dairy farming, cash rent is more popular, since livestock and livestock products are more difficult to divide between tenant and landlord. A few farms are

rented on a cash basis by commercial canning companies. About one-fourth of all the tenants use a combination of a share-cash system in which part of the crops, such as small grains which are easily divided, is on a share basis, while the other crops such as corn, roots, and pasture are on a cash basis. Another one-fourth of the tenants usually share the crops and livestock with the landlord. In such cases the tenant assumes less risk, supplies less capital, and obtains some management assistance from the landlord. The landlord also shares some of the expense, supplies part of the capital, and assumes more risk owing to changes in price and variations in yields.

Occasionally, where hired help is employed the year round, the worker is given at a nominal cost a house, garden space, milk, butter, and eggs. On some farms day labor is employed only at peak periods, especially during seeding and harvesting operations.

FARM EQUIPMENT

Nearly every farm has one or more automobiles. In 1950 there were 2,391 cars on 1,908 farms, 2,458 tractors on 1,659 farms, and 924 trucks on 762 farms. These figures represent estimates for all farms made on the basis of reports from approximately 20 percent of the farms. Other machinery includes manure spreaders, two-bottom plows, harrows, grain drills, mowers, side-delivery rakes, hay loaders, corn planters, and cultivators. A few farmers have small combines, but most threshing is done either cooperatively or privately by threshing machines operated by gasoline engines.

SOILS

Le Sueur County is included in the region of Prairie soils identified on a generalized soil map of Minnesota as the Clarion-Webster soil association.[4] The soils of this county, though originally developed under prairie vegetation, show a stronger influence of forest vegetation than do the soils of the counties within this association to the west and southwest. In general the soils are dark, well supplied with organic matter and lime, medium to fine in texture, and free from stone. Most of them are cultivated and have a high level of fertility.

Most of the soils except those occupying the broad terraces in the Minnesota River Valley have formed from moderately fine textured glacial till. A large part of the lime in this limy clayey till yet remains in the subsoil. The surface soils are moderately dark, except in the strongly rolling areas in the eastern and southern parts of the county, where they are gray. In general the soils have sufficient slope to afford good surface runoff, but on the more level areas they have poor surface runoff and internal drainage and need artificial drainage. Many of the more poorly drained soils have been tiled and made productive. Many depressional areas are enclosed basins that receive runoff water from the surrounding higher land and remain wet the greater part of the year. Artificial drainage of these basins is impracticable because of lack of a suitable outlet or because of the high cost involved in providing an outlet. Wild hay is harvested from many such areas, provided they are not too wet.

[4] McMILLER, P. R. PRINCIPAL SOIL REGIONS OF MINNESOTA. Univ. Minn. Agr. Expt. Sta. Bul. 392, 48 pp., illus. 1947.

Erosion is often destructive on cultivated slopes of more than 6 or 7 percent and it becomes more serious as the slope increases. Some soils in more rolling areas that were once cropped have reverted to permanent pasture or trees because of severe losses of surface soil or gully erosion. At present a few farmers are practicing such simple soil conservation practices as keeping the strongly sloping fields in sod crops for a longer time than was formerly done. Light sandy soils in large level or nearly level fields exposed to strong wind movements have been severely eroded, as is shown by small dunes or drifts along fence rows or other obstructions.

Differing soil conditions determine local differences in the agriculture of the county. Between Montgomery and Waterville, for example, steep slopes and a forest vegetation have had a marked influence on soil formation. As a result, the major soils—Lester, Hayden, and Burnsville—have light-colored surface soils and small quantities of organic matter. Included in this area, however, are numerous lakes and poorly drained soils occupying depressions and former lake basins. A belt of hilly land, with enclosed lakes and low lying areas, occurs not only in the eastern part of the county but also in the southern part extending from Waterville to Kasota (fig. 2). Hills, lakes, and depressions somewhat restrict farming in this area. Much of the land is in grasses and legumes and second-growth forest. The cultivated areas are mainly on sloping land and in many places are erodible.

In other parts of the county a prairie vegetation has dominated soil development, particularly in the northwest where more land is suitable for cropping. Some comparatively large areas must have more adequate drainage before they can reach their maximum production.

SOIL SERIES AND THEIR RELATIONS

Soils differ widely in color, texture, structure, depth of surface layer, drainage, relief, and other characteristics. On the basis of these characteristics, they are classified into series, types, phases, and soil complexes. To show the relations that exist among the different soils of the county members of each soil series are grouped according to the position they normally occupy in the broad landscape. These groups are (1) soils of the glacial upland, (2) soils of the terraces, (3) soils of the alluvial bottom lands, and (4) soils of the depressions. The various soil series of the first three groups, and their characteristics, are given in table 4. The soils of the depressions, mapped in one unit as Peat and muck, are not listed in table 4 because peats and mucks are not classified by soil series.

SOILS OF THE GLACIAL UPLAND

The soils of the glacial upland are the Burnsville, Clarion, Glencoe, Hayden, Lakeville, Lester, Le Sueur, Storden, Webster, and Terril, plus a comparatively narrow belt of Steep land (Lester and Hayden soil materials) that parallels the Minnesota River and lies mostly between the flood plain and the smoother upland. These soils occupy the greater part of the county and are well above the bottom lands and terraces. They have moderately well defined profile layers, are moderately well drained to well drained, and are generally productive. They are suited to corn, small grains, and tame hay.

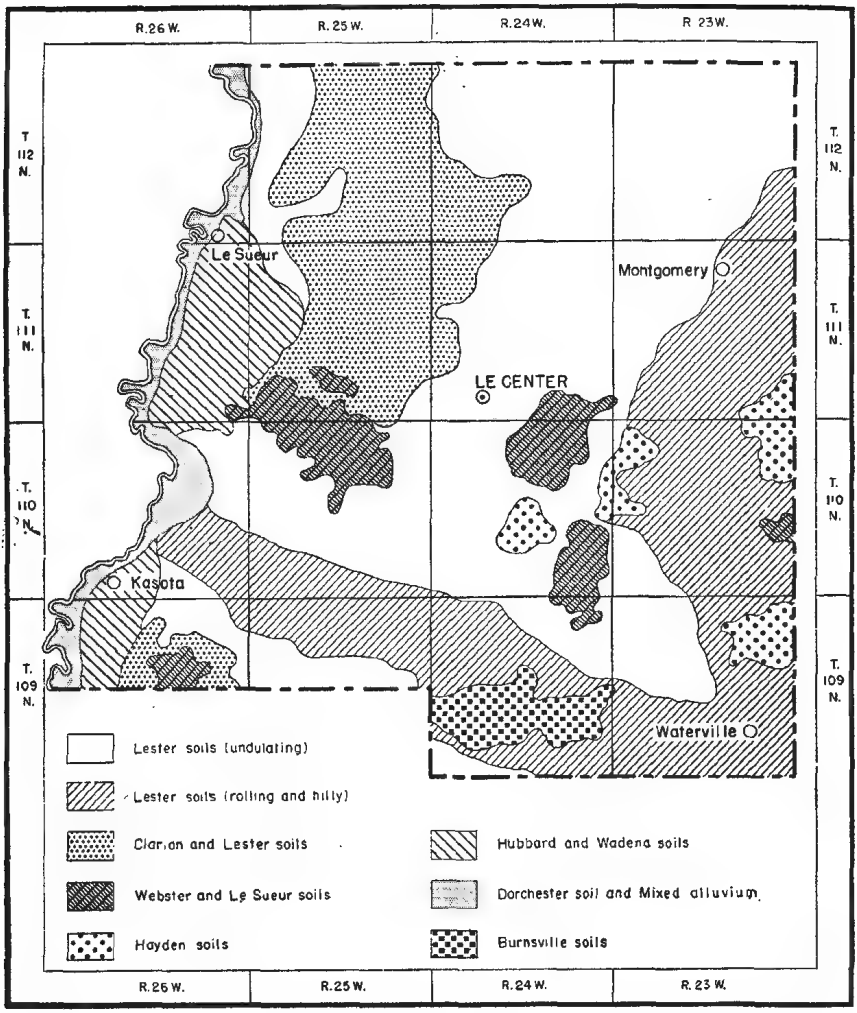

FIGURE 2.—Generalized soil map of Le Sueur County, Minn.

In reaction the soils are slightly acid or neutral in the surface layers and do not require lime for crops with a high lime requirement. In the eastern and southern parts of the county, they occupy more rolling land and usually are somewhat coarser because of variable quantities of sand and gravel in the surface soil and subsoil. The imperfectly drained and poorly drained soils associated with them are black because of their high content of organic matter. Some of the poorly drained soils have considerable lime carbonate in the surface soil and subsoil, for the slow internal drainage has prevented rapid removal of the carbonates by leaching.

With normal rainfall during the growing season, the upland soils are highly productive. When rainfall is abundant, however, the excess water drains slowly, especially on the more nearly level areas, and

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interferes with plant growth. In some places, particularly in Cordova and Lexington Townships, much of the land has been tile drained. Tile drainage has materially benefited the nearly level soils. The excessively drained soils occur chiefly in hilly areas where there is much runoff.

In crossing the county from west to east, the upland soils gradually become lighter colored. Between the areas of dark- and light-colored soils lies a belt where the soils are intermediate in color and somewhat different in other respects from those found to the west or east. In this transitional area, which originally was prairie, there was an encroachment of forest that influenced soil development. The result is a surface soil dark brownish gray at the surface and lighter gray about 2 to 5 inches below.

BURNSVILLE SERIES

The Burnsville soils generally occur in Elysian Township on undulating to hilly relief where the slopes are short and steep. The areas are pitted with peat bogs, marshy spots, ponds, and small lakes. Sand and gravel pits are numerous. The soils have only poorly defined profile layers and consist largely of loose sandy gravelly material mixed with finer materials, such as silt and clay. The underlying soil material is limy. Lime often occurs at depths of 14 inches or less.

A large acreage is still in forest, probably the best use. Water erosion has removed much of the surface soil from cultivated areas, and in some places gullies have formed and cut up the fields.

CLARION SERIES

The Clarion soils were formed under tall native prairie grasses on undulating to rolling relief. Under intensive cropping their originally abundant amount of organic matter and their supplies of plant nutrients have gradually declined. These will eventually have to be replaced, at least in part, if high yields are to be expected.

Most of the acreage is cultivated. The soils are high in productivity and are easy to keep in good tilth. They are among the better soils in the county for corn, small grains, and alfalfa and other tame hay. About 50 to 60 percent is used for intertilled crops, 35 to 40 percent for small grains, and 10 to 15 percent for tame hay meadows and pastures. Some sweet corn is grown for commercial canning.

GLENCOE SERIES

The Glencoe series consists of poorly drained upland soils derived from calcareous till. These soils occur in low nearly level to gently sloping comparatively small tracts, in slightly depressed wet areas, and in low drainageways. Frequently, deposits of local alluvium or colluvium cover them to varying depths. The dark surface soil is high in organic matter and ranges from 14 to 20 inches deep. Carbonates are often found within 20 inches of the surface. Some areas are confined to swales without natural drainage outlets and to old lake bottoms that have either been drained artificially or have naturally dried up. In these places the soils are usually very high in carbonates, a large part of which consists of small shells found on and below the surface. Frequently a thin layer of partly disintegrated peat covers

the surface and gives a fluffy structure to the dry surface soil when it is cultivated.

Corn is better suited than small grains, for small grains tend to lodge. These soils are not very productive unless they are artificially drained and treated with a commercial fertilizer containing phosphate and potash.

HAYDEN SERIES

The Hayden soils have developed in areas where forests prevailed. Originally there was a heavy growth of mixed hardwoods, but now much of the land, except some of the rolling and hilly phases, has been cleared and is being used for crops. In some places both sheet and gully erosion are serious, particularly on land that has not been well farmed.

The Hayden surface soil is of medium texture, mostly a gritty loam. The upper part of the subsoil is generally a silty clay loam. The Hayden soils are slightly more acid than the Clarion and Lester soils but ordinarily do not need lime for sensitive crops. They do need lime if the surface soil is sandy, for then lime has been leached out. The Hayden soils occupy small areas, chiefly in the southeastern townships. In Waterville and Cordova Townships the surface soils are somewhat darker than in other parts of the county.

In general these soils contain less organic matter than either the Clarion or Lester soils and are therefore somewhat less productive. The eroded phases in the cultivated areas have been farmed to corn and small grains. Some of the land is in tame hay meadow and permanent pasture. In some places areas that once were cropped annually are being converted to use for permanent hay meadow or pasture.

LAKEVILLE SERIES

The Lakeville soils are similar to Burnsville soils and are derived from similar parent materials. They developed, however, under grass rather than forest. They occur in complex association with Lester soils.

LESTER SERIES

The Lester soils are transitional between the prairie and forest areas. They have a gray layer underlying a surface soil shallower than the surface soil normally expected in prairie areas. In relief they range from undulating to hilly. They have good surface runoff and internal drainage. Practically all of the acreage occupied by the smoother phases is cultivated. Where the relief is hilly and the slopes are short and steep, most of the land is in forest or in permanent pasture. More peaty and marshy areas occur in the Lester soils than in the Clarion.

Of the cultivated Lester soils, the proportion used for such intertilled crops as corn and soybeans is about the same as it is for the Clarion. The yields are somewhat more variable than those obtained from the Clarion areas because of a lower content of organic matter.

LE SUEUR AND WEBSTER SERIES

The imperfectly drained upland soils belong to the Le Sueur and Webster series. The Webster soils have somewhat poorer internal

drainage than the Le Sueur, for they occupy more nearly level areas where little water is removed by runoff. The Le Sueur soil is slightly more sloping than the Webster, thus permitting better surface runoff and less waterlogging. Both the Webster and Le Sueur soils appear to have formed from somewhat finer textured parent material than that from which the Clarion, Lester, and Hayden soils were formed. They are grassland soils. They have a deep surface soil and a subsoil that is generally somewhat mottled as a result of restricted internal drainage. In these soils the depth of free lime is in many places greater than it is in the Clarion soils. The Webster and Le Sueur are well suited to corn, soybeans, and small grains, but small grains sometimes tend to lodge because of the high nitrogen content in the surface soil.

STORDEN SERIES

The excessively drained Storden soil occurs on hilly areas in association with the predominating Clarion and Lester soils. The profile layers are poorly defined. Much rainfall runs off the surface before it can enter the soil. There is considerable variation in the thickness of the surface soil and in the depth at which carbonates occur. In some places there is as much as 6 inches of dark surface soil; in others there is practically none, or the subsoil is exposed. The subsoil is usually exposed where cultivation has caused accelerated erosion. Most areas are used for permanent hay meadow and pasture; some are in forest.

TERRIL SERIES

The well-drained Terril soils have developed from colluvial materials. They occur as gently sloping to sloping lower slopes in the uplands. The soils are brown and slightly acid, but the underlying till, found at a depth of about 40 inches, is calcareous. Use and management practices are similar to those for Clarion soils on comparable slopes.

SOILS OF THE TERRACES

The soils of the terraces are the Copas, Estherville, Hubbard, Kasota, and Wadena. They have sandy and gravelly subsoil overlain by a generally finer textured surface soil. They are characteristically dark and are underlain by calcareous sands and gravel at varying depths, usually within 30 inches of the surface. In texture, the surface soils range from sandy loams to silt loams, the sandy loams predominating. Areas border streams but are above overflow. The largest terrace, near the town of Le Sueur, is called the Le Sueur Prairie by the local inhabitants. This is a broad nearly level plain lying between the bottom land of the Minnesota River and the originally wooded upland.

The water-holding capacity of many of the terrace soils is low. They are therefore droughty, and especially so in seasons with less than average rainfall. The Kasota and Wadena soils have appreciable quantities of silt and clay in the upper subsoil, which prevents crops from drying out as rapidly as on the other terrace soils. Wind erosion is often serious, especially where the fields are large and unprotected by groves of trees or other barriers. In spring and early in summer, the drifting soil often damages crops by burying or cutting off the young plants.

COPAS SERIES

The Copas soils are formed from medium-textured material and are underlain by limestone or sandstone at depths ranging from 12 to 20 inches. In some places exposed bedrock makes the soil too stony for crops and best for permanent pasture.

ESTHERVILLE SERIES

The Estherville soil has a thin surface soil and subsoil; limy gravel is at depths of 12 to 18 inches from the surface. With the gravel at such shallow depth, the soil is extremely droughty and therefore poor for crops.

HUBBARD SERIES

The Hubbard soils are somewhat more sandy throughout the profile than the other terrace soils. The surface soil and subsoil both have a fine sandy loam texture. At depths of 18 to 34 inches this texture grades into stratified sand and mixtures of sand and gravel. Crops suffer more from drought in the drier parts of the growing season than on the Kasota and Wadena soils, and the surface soil frequently drifts when it is not covered by grass vegetation. In some areas the dunelike relief suggests that the wind shifted the soil considerably, long before it was farmed.

KASOTA SERIES

The best agricultural soil of the terraces is Kasota silt loam. It has a moderately heavy surface soil and upper subsoil and is underlain by gravel at depths ranging from 26 to 30 inches.

WADENA SERIES

The moderately productive Wadena soils have developed under a grass vegetation. They are underlain by limy sand and gravel at about 26 to 30 inches, but frequently these materials occur closer to the surface.

SOILS OF THE ALLUVIAL BOTTOM LANDS

The soils of the alluvial bottom lands are the Dorchester and Mixed alluvium, which is not classified by soil series and types. Areas of these soils along streams are subject to periodic flooding. Some areas along the Minnesota River are planted to crops, but most are used for permanent pastures. The soils are highly fertile. Corn is the principal crop where they are satisfactorily drained. When rainfall is high, particularly in spring, these areas are often flooded and seeding is delayed beyond the time when crops are planted on the upland. Late spring frosts sometimes damage sensitive plants.

DORCHESTER SERIES

The Dorchester soil consists of recent alluvium, generally limy, that is deposited from silt-laden streams when the land is flooded. The surface soil and subsoil are extremely variable. They usually consist of fine material interbedded with layers of sand. Drainage is slow, especially if the soil consists of fine-textured material throughout the upper 3 feet, as it sometimes does. Large areas of the soil are cropped, and high yields are common if the season is not excessively wet. The wetter parts are commonly used for pasture or woodland.

SOILS OF THE DEPRESSIONS

The soils of the depressions—mapped in one unit as Peat and muck—are widespread throughout the county. There is some peat soil on many farms. Nearly all the peat is derived from sedges, reeds, and native grasses. These peat and muck soils are usually too wet to be cropped unless they have been artificially drained. Wild-grass hay is cut from many bogs during the drier part of the year and is an important source of feed for livestock. The bogs are also frequently pastured.

DESCRIPTIONS OF THE SOILS

In the following pages the soils of Le Sueur County are described in detail and their agricultural relationships are discussed. Their location and distribution are shown on the accompanying soil map, and their approximate acreage and proportionate extent are given in table 5.

In a semidetailed survey such as was made of this county, two soils having a small difference in texture, but of the same series, and otherwise similar in characteristics and having about the same crop producing ability are not separately mapped. For example, areas of Clarion silt loam may include smaller areas that have a surface texture of a loam or even a silty clay loam. In the Clarion soils the silt loam type is most extensive and other types are considered as inclusions.

Beach sand (BA).—This sand is on some of the lake shores in the southern part of the county. It is generally bare of vegetation and is nonagricultural.

Burnsville sandy loam, eroded undulating phase (BC).—Erosion has affected this phase considerably; its surface soil is much lighter colored than it would be if it were not eroded. Much of the surface soil has a low content of organic matter, and the light-colored subsoil is exposed in many places. Slopes seldom exceed 7 percent. A large part of this soil has been cleared and used for crops, though some has been abandoned or is used as pasture. The productivity is generally low.

Burnsville sandy loam, rolling phase (BE).—Except for occurring on a rolling surface (7 to 13 percent slopes) and not being eroded, this soil is similar to the eroded undulating phase. Only a small area has been cleared and used for crops (pl. 2, *A*).

Burnsville sandy loam, eroded rolling phase (BB).—In small areas, particularly on slopes of more than 10 percent, erosion of this soil has been severe. Other areas of it are not so severely eroded and are similar to the rolling phase of Burnsville sandy loam. This phase occurs in association with other Burnsville soils.

Burnsville sandy loam, hilly phase (BD).—Slopes of this soil range from 13 to 25 percent. Bodies are associated with other Burnsville soils, particularly near and surrounding some of the lakes in the morainic hills in the southern part of the county. Owing chiefly to the hilly relief, this soil is considered unsuitable for crop production. It is very highly susceptible to erosion and very low in productivity. Most of it is still occupied by the original forest. A few cleared eroded areas have gullies, some of which are so deep as to cut into and undermine the coarse-textured subsoil.

Clarion silt loam, undulating phase (CD).—This upland soil has moderately well defined profile layers. It has formed from calcareous glacial till under prairie grasses on 2 to 7 percent slopes. It has medium surface runoff and internal drainage and is comparatively free of stone on and below the surface.

The surface soil, 12 to 14 inches thick, is dark brownish-black granular slightly acid silt loam. It is well supplied with organic matter, usually has good tilth when cultivated, and has a high water-holding capacity. The 6- to 8-inch subsurface soil is brownish-black or brownish-gray, slightly acid heavy compact silt loam or silty clay loam of subangular blocky structure. Streaks and tongues of darker infiltrations carried down from the surface soil are common in this layer. The neutral subsoil, 10 to 12 inches thick, is dark yellowish-brown compact silt loam to silty clay loam. When disturbed by slight pressure, the subangular blocky aggregates break down readily. The parent material is mottled light yellowish-brown or gray friable calcareous loam that frequently contains inclusions of sandy material.

Practically all the acreage is cultivated. At the time of survey 86 to 90 percent of the land was in crops. From 35 to 40 percent was used for intertilled crops, 45 to 50 percent for small grains, and 10 to 15 percent for tame hay or pasture. Corn harvested for grain and soybeans are the principal intertilled crops, and some sweet corn is grown for commercial canning. The small grains, in order of importance, are oats, spring and winter wheat, barley, and flax. Estimated average acre yields are shown in table 7.

This excellent agricultural soil is highly productive under good management and is not seriously affected by erosion (pl. 2, *B*). When this survey was made, farmers did not generally practice a standard system of crop rotation, but some followed a cropping plan that included corn, grain, corn, and grain seeded with a grass mixture. The land then remained in hay for 2 years or more. Barnyard manure was almost the only fertilizer used, and it was generally applied to fields planted to corn.

A good crop rotation that includes a legume crop, such as alfalfa, is desirable for maintaining the supply of organic matter. Nearly all the farmers raise livestock. Recommended for farmers having comparatively large herds is a 5-year rotation of corn, grain with alfalfa, alfalfa hay for 2 years, and then corn again. Other rotations are recommended in table 6.

Whatever system of soil management is practiced, the use of some commercial fertilizer to supply phosphate and potash is recommended. The kinds and amounts to supply will depend on soil tests. If applied at least once during a crop rotation, barnyard manure will help maintain the supply of organic matter, but it will not long maintain the needed quantities of phosphate and potash. In the crop rotation, commercial fertilizers can be applied to the corn as row applications or they can be broadcast on fields that are to be seeded to grain with a legume-grass mixture. If fertilizer is broadcast, each crop in the rotation receives some benefit from it.

Clarion silt loam, eroded undulating phase (CB).—Except for having lost some of its surface soil through erosion, this soil is similar to the undulating phase. The two soils have about the same degree

TABLE 5.—*Approximate acreage and proportionate extent of soils mapped in Le*

Symbol	Soil	Cleveland Township	Cordova Township	Derrynane Township	Elysian Township	Kasota Township	Kilkenny Township	Lanesburgh Township	Le Sueur Township	Lexington Township	Montgomery Township	T
		Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	
BA	Beach sand	52	13	------	105	23	35	54	------	9	2	
	Burnsville sandy loam:											
BB	Eroded rolling phase	------	------	------	802	------	------	------	------	------	------	
BC	Eroded undulating phase	------	------	------	82	------	------	------	------	------	------	
BD	Hilly phase	------	------	------	1,204	------	------	------	------	------	------	
BE	Rolling phase	------	------	------	128	------	------	------	------	------	------	
	Clarion silt loam:											
CA	Eroded rolling phase	347	------	682	325	828	------	139	------	211	24	
CB	Eroded undulating phase	1,520	------	362	428	2,939	------	35	------	69	------	
CC	Rolling phase	23	------	13	------	9	------	70	------	------	32	
CD	Undulating phase	359	------	2,297	166	78	------	2,237	------	374	203	
	Copas loam:											
CE	Nearly level phase	------	------	------	------	1,333	------	------	------	------	------	
CF	Undulating phase	------	------	------	------	1,985	------	------	------	------	------	
DA	Dorchester silt loam	------	------	------	------	1,367	------	------	348	------	------	
EA	Estherville sandy loam	------	------	------	260	235	------	------	------	------	------	
GA	Glencoe and Webster silty clay loams	981	731	1,179	815	650	812	1,079	------	458	1,100	
GB	Glencoe silt loam	765	383	1,511	384	325	524	1,874	------	610	1,258	
GP	Gravel pits [2]	------	------	------	15	31	------	6	5	------	------	
	Hayden silt loam and loam:											
HA	Eroded hilly phases	------	137	------	307	------	637	------	------	------	161	
HB	Eroded undulating phases	------	50	------	273	------	46	------	------	------	30	
HC	Hilly phases	------	34	------	64	------	57	------	------	------	13	
HD	Rolling phases	------	22	------	264	------	293	------	------	------	158	
HE	Severely eroded rolling phases	------	799	------	510	------	934	25	------	------	348	
HF	Undulating phases	------	73	------	38	------	209	------	------	------	76	
	Hubbard fine sandy loam:											
HG	Eroded rolling phase	------	------	------	------	6	------	------	28	------	------	
HH	Eroded undulating phase	------	------	------	13	------	------	------	412	------	------	
HK	Moderately steep phase	------	------	------	------	7	------	------	191	------	------	
HL	Nearly level phase	------	------	------	------	36	------	------	127	------	------	
KA	Kasota silt loam	------	------	------	50	255	------	------	------	------	------	
	Lester-Lakeville complex:											
LA	Eroded rolling phases	------	------	61	351	7	------	------	------	43	------	
LB	Hilly phases	------	------	------	151	------	------	22	------	------	------	
LC	Undulating and rolling phases	------	4	55	71	------	9	8	------	4	3	

	Lester silt loam:										
LD	Eroded hilly phase	342	363	27	535	917	1,041	211		143	237
LE	Eroded rolling phase	2,281	2,901	2,147	2,520	1,711	5,357	2,508		4,420	4,116
LF	Eroded undulating phase	3,812	2,618	584	1,658	1,218	1,416	292	4	2,831	2,605
LG	Hilly phase	48	48	5	297	133	263	49		24	46
LH	Rolling phase	236	391	268	705	283	1,190	653		709	692
LK	Severely eroded rolling phase	1,224	802	205	1,461	861	2,029	62		593	334
LL	Undulating phase	702	1,526	2,900	568	61	910	3,134		2,562	1,952
LM	Le Sueur silty clay loam, nearly level phase	52		2		268		60			
	Limestone quarry [2] [3]					168					
MA	Marsh	751	1,613	1,012	2,031	711	1,200	150	13	624	403
MB	Mixed alluvium	9	25	146	97	2,451	358	335	501	120	66
PA	Peat and muck	3,578	3,364	3,816	2,743	1,249	3,570	2,603		4,061	
SA	Steep land (Lester and Hayden soil materials)				16	1,420			264		5,166
SB	Storden silt loam, hilly phase					25				1	
TA	Terrace escarpment					85	36	19	38		3
	Terril silt loam:										
TB	Gently sloping phase					125					
TC	Sloping phase					326			102		
	Wadena loam:										
WA	Nearly level phase			9		356		20	1,208		
WB	Rolling phase					56			36		
WC	Undulating phase					140			311		
	Webster and Le Sueur silty clay loams:										
WD	Nearly level phases	3,171	3,278	3,954	372	531	548	3,993		2,020	1,272
WE	Undulating phases	1,802	2,330	1,091	235	1,104	930	1,244		2,245	1,473
	Total	22,055	21,505	22,326	20,044	24,292	22,404	20,882	3,588	22,131	21,773

[1] Less than 0.1 percent.

[2] Not described in text because it has no agricultural value.

of slope, but this eroded soil has not been farmed so carefully. Its surface soil is thinner because of erosion, but fertility can be restored to about the same level as that of the undulating phase by using good management practices.

Clarion silt loam, rolling phase (Cc).—This soil has about the same kind of surface soil and subsoil as the undulating phase, though its surface soil is somewhat shallower. The relief is stronger (7 to 13 percent slopes) and there is a greater loss of water by runoff. Under good management this soil is about as productive as the undulating phase. It requires somewhat more skill in farming, however, for it is more susceptible to erosion. Cropping practices for the two phases are the same.

Clarion silt loam, eroded rolling phase (CA).—This phase has slopes and soil characteristics about the same as those of the rolling phase, but some parts of its surface soil have eroded. The surface soil is consequently thinner and has a lighter color indicating a lower content of organic matter. Farming methods that provide for restoration of organic matter will have to be employed in order to give this soil its original productivity.

Copas loam, nearly level phase (CE).—This nearly level soil occupies old terraces. It has developed from loamy material underlain by sandstone or limestone bedrock at comparatively shallow depths. The depth to bedrock ranges from less than 12 to more than 20 inches, there being considerable variation within short distances. In some places the rock is exposed at the surface. The soil has a moderate content of organic matter and works to a good seedbed. It is permeable to plant roots, but the bedrock restricts full root development in some places.

The 6- to 8-inch surface soil is slightly acid brownish-black loose friable loam with a slightly granular structure. The subsurface layer, 6 to 7 inches thick, is dusky reddish-brown friable loam. It has a subangular structure and is slightly heavier than the surface layer but has about the same degree of acidity. The 10- to 12-inch subsoil is slightly acid dark reddish-brown friable loam of subangular structure. In the lower part of the subsoil some sand is frequently embedded in the finer material, thus making the texture more gritty.

Where the depth to bedrock is at least 18 to 20 inches, this soil produces fair crops if the rainfall is abundant and well distributed during the growing season. Crops commonly grown are corn, small grains, and tame hay. Areas where the bedrock appears at the surface are used for grazing. Many such areas are in permanent pasture. A few areas are thinly wooded and have patches of grasses among the trees.

Copas loam, undulating phase (CF).—This soil has slopes of not more than 3 percent. In other respects it is similar to the nearly level phase and is used in the same way. Large areas are used for permanent pasture because bedrock outcrops are numerous.

Dorchester silt loam (DA).—This bottom land soil occurs along the Minnesota River and some of its tributaries. It consists of recent stream-deposited materials moderate in texture and high in lime, and is subject to flooding when the rivers are high, especially during the spring thaw.

The surface soil is light brownish-gray mellow friable calcareous silt loam, 16 to 18 inches deep. Underlying this to a depth of 36 inches or more is light brownish-gray friable calcareous silt loam. Below this are interbedded layers of silt and sand of variable thickness. The whole profile contains appreciable quantities of lime.

The chief variations are in the texture of the surface soil and the character of the interbedded layers in the subsoil. In the subsoil are narrow bands, thin lenses, or pockets of sand or silt laid down during periods of flooding. Within some areas are small poorly drained tracts that have slow surface runoff and internal drainage. These are so low that water often stands on the surface for prolonged periods, and in wet years the land remains idle the whole season.

This soil is both pastured and cultivated. Corn is the principal crop. Small grains frequently lodge because of the high content of nitrogen in the soil. Occasionally the crops are drowned out when streams overflow. Originally, the included more poorly drained areas supported a heavy growth of maple, basswood, and elm, with sedges and reeds in the wetter places. At present most of these poorly drained areas are in pasture or forest.

Estherville sandy loam (Ea).—This nearly level to gently undulating soil occurs on high terraces, mostly in small areas near major streams. It developed under prairie grasses. It is a source of road gravel, and many pits have been opened.

The profile is weakly to moderately well defined. The 8 to 9 inches of surface soil consists of brownish-black friable granular slightly acid sandy loam. This layer gradually grades into a dark-brown friable sandy loam subsoil composed of somewhat angular aggregates. The lower subsoil is slightly acid, and in places appreciable quantities of sand and gravel are embedded in its silt and clay. At depths of 12 to 20 inches from the surface, the lower subsoil grades into a bed of dark-brown to moderate yellowish-brown loose calcareous sand and gravel that is frequently 10 feet or more thick.

Crop yields are low because the soil is comparatively shallow over the deep bed of sand and gravel. In seasons of normal rainfall this soil produces fair yields of corn and of small grains, such as oats. Fall-sown rye often does well. Occasionally a stand of clover may be satisfactory, provided a fair quantity of rainfall is well distributed during the growing season. This soil is not well suited to alfalfa. Little can be done to reduce its droughtiness or increase its water-holding capacity. Stable manure produced on the farm could be used to good advantage on this soil.

Glencoe silt loam (Gb).—This poorly drained soil has developed from calcareous glacial till. It is found along upper and lower drainageways and in level basinlike depressions in association with the Clarion, Lester, Le Sueur, and Webster soils. In some of the lower lying excessively wet areas a thin layer of decomposed peat covers the surface of this soil. In other places 6 to 8 inches of dark material washed in from surrounding higher lands covers the surface.

The 14- to 16-inch surface soil is black to brownish-black heavy silt loam, high in organic matter and generally slightly acid to neutral. The fine granular structure of this layer is impaired if the soil is plowed when too wet. The upper part of the subsoil, 6 to 8 inches thick, is medium olive-gray clay loam or moderately plastic silty clay

that is compact and tends to be cloddy. Its reaction is usually neutral, although occasionally it may be appreciably alkaline. The lower part of the subsoil, from 8 to 11 inches thick, is light olive-gray calcareous silty clay mottled with weak yellow, gray, and brown. The substratum is medium-gray or light olive-gray sandy clay or clay loam calcareous glacial till, which is mottled with light yellowish gray. In many places the till is stained with iron compounds. Concretions of calcium carbonate may be present.

Included with this soil is another that has an abundance of lime carbonate in all layers but is otherwise similar in many respects. This inclusion also occurs in low areas and depressions, some of which were once old lake bottoms and sloughs that have been artificially drained or dried up. The surface soil has a high content of organic matter; in places it is covered with a 3- to 6-inch layer of peat. To a depth of 15 to 16 inches the surface soil is dark-gray to black finely granular silty clay loam. It is highly calcareous; snail shells are found on and below the surface in some places. The upper part of the subsoil, 7 to 8 inches thick, is brownish-black or dark-gray silty clay loam or silty clay that becomes grayer with depth. It is compact and hard when dry and forms hard clods when the soil is disturbed. The lower 10 inches of the subsoil is light olive-gray silty clay mottled with yellow and brown. At this depth the soil material is cloddy, though when handled the clods break readily into smaller irregular fragments. Iron stains are present in some places in this limy layer. The substratum consists of mottled gray and yellow or reddish-brown sandy clay glacial till with some iron and lime concretions. At depths of 34 to 36 inches the soil is normally saturated with water, although it is less so in dry seasons when the water table recedes.

After satisfactory drainage Glencoe silt loam is productive if a commercial fertilizer containing phosphate and potash is used. Most of it is used for pasture or meadow, owing to its poor natural drainage. Some of it, however, is tile drained and used for corn, small grains, and other crops. It is better suited to corn than to small grains, for the grains tend to lodge because of the high content of nitrogen in the soil. Corn may be affected by excessive soluble salts that interfere with plant growth, although years after the land has been drained these so-called alkali spots gradually disappear. When this soil occupies part of a field consisting mostly of Clarion or Lester soils, it is normally farmed like them.

Glencoe and Webster silty clay loams (GA).—This complex is similar to Glencoe silt loam but has a greater relief that allows better runoff. The slopes range from 2 to 5 percent. In most places this complex is associated with Glencoe silt loam, which occupies the lower positions where slopes seldom exceed 1 percent. The complex extends up the narrow swales between areas of other better drained upland soils. Frequently a thin coating of colluvial material has washed onto it from adjacent higher lands. Although somewhat better drained than Glencoe silt loam, this complex has imperfect internal drainage and remains wetter longer in spring after rains than do the associated better drained soils. Areas of this complex are widely distributed in association with the Clarion and Lester soils. Included with it is a calcareous soil similar to the inclusion described under Glencoe silt loam. Some areas of nearly level Glencoe silt loam are also included.

The surface soil of this complex is high in organic matter and generally well supplied with lime. It is productive and suitable for corn, soybeans, and small grains. Alfalfa frequently winterkills because of excess moisture in the soil; other tame hay crops do well.

Hayden silt loam and loam, rolling phases (HD).—These phases have moderately well defined profile layers and have developed from limy glacial till. Most areas are rolling, the slopes ranging from 7 to 13 percent. Surface runoff is medium to rapid, and internal drainage is nearly everywhere adequate. Owing to the moderately strong slopes, considerable water is lost through runoff. Except for surface soil texture the two soils of this undifferentiated unit are the same in profile characteristics.

The 7- to 8-inch surface soil is a light brownish-gray very friable floury loam or silt loam having a more or less platy structure. Although the surface soil is moderately acid, the deeper subsoil is generally well supplied with lime. It is seldom necessary to apply lime, even for sensitive crops such as alfalfa and sweetclover. The surface soil is low in organic matter but has a good water-holding capacity because of the quantity of silt and clay it contains. The subsurface layer, about 3 to 5 inches thick, is a light yellowish-brown or pale-brown slightly acid loam or silt loam. It is mellow and floury like the surface soil but somewhat more compact.

The upper subsoil, 20 to 24 inches thick, is a moderate yellowish-brown compact silty clay loam with a blocky structure. The light grayish floury material coating the soil aggregates in this layer has been carried down from overlying layers. The upper subsoil is hard and somewhat indurated when dry but soft and permeable to plant roots when wet. The lower subsoil is a clay loam slightly more compact and indurated than the upper subsoil. It is somewhat darker than the layer above because some dark-brown soil material has washed down from the overlying layers. Percolating water has removed most of the carbonates, making the subsoil slightly acid. In some areas the subsoil is interbedded with thin strata of sand and fine gravel. The parent material is similar to that of the Clarion and Lester soils and consists of limy till.

Stronger relief, lower content of organic matter, and greater loss of surface soil through erosion make these rolling phases less productive than Clarion silt loam, undulating phase, and Lester silt loam, undulating phase. Many wooded areas occupy these soils and many of them are used as pastures. The small-grain crops are similar to those grown on the Lester and Clarion soils. Corn is the important cultivated crop (pl. 2, *C*).

These are fair to good agricultural soils. When worked, they have properties that permit the preparation of a good seedbed. They are not droughty because they contain sufficient fine-textured material, such as silt and clay, to give them a good water-holding capacity.

A rotation commonly used is corn, grain, corn, grain seeded with a legume-grass mixture, and 1 or 2 years of hay. In spring barnyard manure is usually applied to fields that are to be plowed and planted to corn. Since these soils are low in organic matter, at least 2 to 3 years of hay should be included in a 4-year rotation. Recommended rotations are listed in table 6. The quantities and kinds of fertilizer needed should be determined by soil tests.

Hayden silt loam and loam, undulating phases (HF).—More gentle relief (0 to 7 percent slopes) is the chief difference between these undulating phases and the rolling phases of Hayden silt loam and loam. Profile characteristics are similar except there has been almost no erosion of these undulating phases and their soil layers are probably a little thicker than those of the rolling phases. These undulating phases occupy small tracts in association with other Hayden soils. Practically all the land is cleared and used for crops such as those grown on the rolling phases. A few areas are wooded.

Hayden silt loam and loam, eroded undulating phases (HB).—Erosion has removed some surface soil from these phases, but in all other respects they are similar to the undulating phases. Since only a small amount of organic matter was in the Hayden soil in its virgin condition, the losses of surface soil subsequent to clearing have resulted in lower productivity. The soil structure has also deteriorated, thus making proper cultivation more difficult. These phases tend to bake and form hard clods when plowed or cultivated.

Hayden silt loam and loam, severely eroded rolling phases (HE).—Considerable erosion has taken place on these rolling phases (pl. 3, *A*). As a result they are shallow, and in many places the light-colored subsoil is exposed at the surface. Surface runoff is considerable because slopes range from about 7 to 13 percent and the supply of organic matter is meager. No great quantity of rainfall can be held, for loss of organic matter has decreased the absorptive ability of the soils. These phases occur in the same general localities as the uneroded rolling phases. Some of the land that was cleared has reverted to permanent pasture.

Hayden silt loam and loam, hilly phases (HC).—Stronger relief (13 to 20 percent slopes) is the main difference between these phases and the rolling phases of Hayden silt loam and loam. The surface soil of these hilly phases is considerably thinner than that of the rolling phases, but other profile features are the same. These hilly phases occupy small areas intermingled with other Hayden soils.

Only a small acreage of these hilly phases has been cleared and used for crops; some is used for permanent pasture but most of it is wooded. Low content of organic matter and strong relief are the chief reasons why these phases are not well suited to crops. Where the land is farmed, it should be kept in sod crops at least 60 percent or more of the time, and perhaps the steepest slopes should be kept permanently in grass and used only as meadow or part-time pasture. Some areas can be used for pasture, but good management is necessary to insure adequate feed.

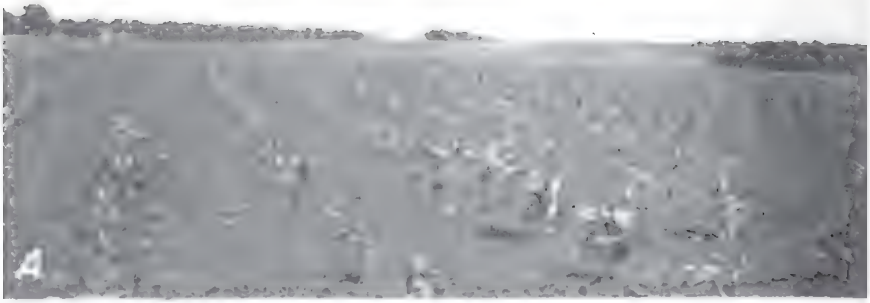
Hayden silt loam and loam, eroded hilly phases (HA).—Areas occupied by these phases were originally occupied by the uneroded hilly phases, but considerable loss of surface soil caused by erosion has reduced the productivity to a low level. Much of the acreage is used for permanent pasture. Some of the land once cropped has reverted to permanent pasture, the productivity having been lowered by severe erosion.

Hubbard fine sandy loam, nearly level phase (HL).—This soil has developed from sandy material under prairie vegetation and is under-

A, Erosion of Hayden silt loam and loam, severely eroded rolling phases, is shown by lighter colored areas.

B, Steep land (Lester and Hayden soil materials) is confined to a narrow belt between the flood plain or higher terraces of the Minnesota River and the rolling upland.

C, Corn in foreground on Wadena loam, nearly level phase; Terril silt loam, sloping phase, in middle ground; Lester silt loam, eroded rolling phase, and Steep land (Lester and Hayden soil materials) in background.



A, Corn growing on Wadena loam, undulating phase.
B, Cattle grazing on Webster and Le Sueur silty clay loams, nearly level phases.
C, Webster and Le Sueur silty clay loams, undulating phases, showing areas of slight depression (darker spots), which often remain wet late in spring and delay seeding.

lain by loose sand and gravel. Like Wadena loam soils it occurs on terraces and has a dominantly nearly level surface. The somewhat uneven surface is caused partly by wind erosion, which moves the soil from one place and deposits it in another. The common dunelike hills, formed by the wind or water, have their longest axis running from northeast to southwest. The soil has excessive drainage, dries out rapidly, and retains little moisture for growing crops.

The 8- to 10-inch surface soil is medium acid dusky-brown to brownish-black loose fine sandy loam. Because it is loose and sandy, this layer is susceptible to wind erosion and drifts considerably when not protected with vegetation. The subsoil, 10 to 12 inches thick, is a moderate-brown to dark-brown slightly coherent sandy loam, less acid than the surface soil. At a depth of about 20 inches is a yellowish-brown loose incoherent loamy fine sand or fine sand. Lime carbonates are generally leached to a depth of 6 feet or more, and the soil material is acid.

Because of its coarse texture and low water-holding capacity, crops on this soil suffer from drought, particularly in dry seasons and in prolonged rainless periods. Small grains, corn, and tame hay are grown. A crop rotation should include at least 2 years of hay or rotation pasture. Rotations suitable for this soil are given in table 6. To lessen the damaging effect of soil drifting, crops should be planted in comparatively narrow strips, the small grains and intertilled crops being separated by strips of hay crops. The strips should be at right angles to the prevailing wind direction and of sufficient width to reduce drifting as much as possible.

Hubbard fine sandy loam, eroded undulating phase (HH).—This soil differs from the nearly level phase in having undulating relief (3 to 7 percent slopes) and in being eroded. Like the nearly level soil, it has medium to rapid runoff and rapid internal drainage and no stones to interfere with cultivation. In years of liberal and well-distributed rainfall crop yields are fair. The soil warms rapidly in spring and can be worked and sown early to grains. Occasionally strong winds damage the young seedlings and cause the soil to pile up in drifts along fence rows and other barriers.

Although the soil is fairly well supplied with mineral nutrients, it is low in organic matter and generally needs lime. The low water-holding capacity of the surface soil and subsoil is the chief factor limiting crop production. In some places, particularly in cropped areas where improper soil management was employed, much surface soil has been washed away.

Considerable skill in handling this soil is necessary to obtain maximum production. Since rainfall is often unevenly distributed in the growing season, crop yields are usually poor to fair.

Hubbard fine sandy loam, eroded rolling phase (HG).—Much of the soil is still cultivated, though erosion is severe in many fields. In some places at least half of the original surface soil has been lost and small gullies have disfigured the surface. Tillage is difficult in these eroded areas. Slopes range from 7 to 13 percent.

This soil is inferior to the smoother Hubbard soils for agriculture. Its surface soil contains less organic matter and usually holds less water.

Hubbard fine sandy loam, moderately steep phase (Hk).—Much of this soil has greater relief (slopes of 13 percent or more) but otherwise resembles the eroded rolling phase of Hubbard fine sandy loam. It is considered poorly suited to farming, and little of it is used for crops. Erosion is severe in most cultivated fields; gullies have formed in some and made tillage difficult. In the cultivated fields erosion has caused some variation in texture of the surface soil. In severely eroded spots much of the fine material originally present in the soil has been washed away, leaving the coarser sands and gravel.

Kasota silt loam (Ka).—This prairie soil underlain by calcareous gravel occupies older terraces lying well above the river bottoms. It is not subject to flooding and it ranges from nearly level to very gently undulating (2 to 3 percent slopes). Surface and internal drainage are nearly everywhere medium.

The surface soil, 8 to 9 inches thick, is brownish-black to black mellow granular silt loam. Streaks and tongues of the black surface soil extend into the moderately acid subsoil, which ranges from 14 to 16 inches thick. The upper part of the subsoil is moderate-brown to dark yellowish-brown moderately acid silty clay loam of subangular structure. It becomes hard when dry and sticky when wet. The lower subsoil, a brownish-gray angular heavy silty clay loam, is like the upper subsoil in being somewhat sticky when wet and hard when dry. At depths of about 29 to 35 inches mixed calcareous coarse sand and fine gravel are encountered. In many places this mixed material reaches to a depth of 10 feet or more.

This is a productive soil because it has a good amount of fine-textured material over the sand and gravel. When cultivated it develops a good tilth, is readily permeable to roots, and is generally not subject to severe drought. Small grains, corn, and tame hay are the principal crops grown. Because of its relief, it can be farmed a little more intensively than the less sloping phases of the Clarion and Lester soils without severe damage from erosion. Any of the 3- or 4-year rotations given in table 6 are suitable for this soil. In extremely dry periods during the growing season, crops occasionally suffer from drought because the underlying sand and gravel lie comparatively close to the surface and do not permit a large reservoir for water.

Lester-Lakeville complex, undulating and rolling phases (Lc).—In this complex are two soils that developed from glacial till and modified material in such a closely mixed pattern that they could not be shown separately on the soil map. The land surface ranges from gently undulating to rolling (0 to 13 percent slopes). Most of the complex consists of undulating and rolling phases of Lester silt loam (see p. 31) and the undulating and rolling phases of Lakeville loam and Lakeville fine sandy loam.

The Lakeville soils have a dark to moderately dark loam and fine sandy loam surface soil and a subsoil of sandy loam or of incoherent mixtures of sand and gravel. They are similar to the Burnsville soils and are derived from similar material but were developed under a grass rather than a forest vegetation.

Some of the complex has been cleared and used for crops, but a large part is still wooded and much is used for pasture. The complex is moderately productive, considered as a whole, but the productivity is

better where the Lester soils predominate and poorer where the Lakeville soils predominate.

Lester-Lakeville complex, eroded rolling phases (LA).—Slopes of this complex range from 7 to 13 percent. The land has been cleared and was once used for crops, though parts of it are now forested. Much of the original surface soil has been lost, and in some places gullies have cut into the fields and made tillage difficult. This complex is associated with areas of Lester soils.

Lester-Lakeville complex, hilly phases (LB).—Stronger slopes are the main point of difference between this complex of hilly phases and the complex of undulating and rolling phases. The small areas of this complex are mixed with the other Lester-Lakeville complexes but occupy rougher positions, such as small knolls and hillocks. This hilly complex is best suited to forestry, and most areas are wooded. Cleared areas are suitable for pasture, but if they are overgrazed erosion becomes serious and gullies develop.

Lester silt loam, rolling phase (LH).—The topography of this soil is normally more variable, particularly more strongly rolling, than that of Clarion soils. Slopes range from 7 to 13 percent. The soil is subject to severe sheet and gully erosion, both of which are especially pronounced on slopes in the southern parts of the county. Such eroded areas have been separated on the soil map.

This soil has moderately well defined profile layers and is derived from the same kind of material as the Clarion soils. It differs from the Clarion chiefly in having a surface soil that is not so dark or deep. The 8- to 10-inch surface soil is brownish-gray to brownish-black friable slightly granular silt loam that is generally slightly acid. This layer contains less organic matter than the corresponding layer of Clarion soils but is just as permeable to roots and has about the same water-holding capacity. The lower part of the surface layer is distinct gray or light brownish gray and has a slight platy structure that developed through the influence of the native forest vegetation. The slightly acid or neutral subsurface layer, a light brownish-gray to very pale-brown moderately compact heavy silty clay loam, has blocky structure and becomes hard when dry and sticky when wet. The aggregates in this layer have a gray coating and under slight pressure readily break into smaller yellowish-brown aggregates. The subsoil grades from light brownish gray or very pale brown in the upper part to dark yellowish brown in the lower. It consists of heavy compact silty clay loam that is hard when dry and sticky when wet. It has a blocky structure and is medium acid in the lower parts. The parent material is calcareous glacial till of loam texture and is often mottled with light yellowish brown and gray.

This soil does not have uniform color and texture in various parts of the county. The areas of it associated with the Hayden and Burnsville soils are definitely lighter in color. In the southern part of the county, particularly in the southern tier of townships among the numerous lakes, the surface soil may vary from loam to sandy loam, and greater quantities of sand and fine gravel may be embedded in the silt and clay of both the upper and lower subsoil.

Practically all of this soil is cultivated. About 45 to 50 percent is used for small grains, 35 to 40 percent for intertilled crops such as

corn and soybeans, and 10 to 15 percent for tame hay and pasture. Corn, including some sweet corn grown for cash sale, is the most important crop. About the same small grains are grown on this soil as on the Clarion soils, but the yields are somewhat more variable. Where this soil occurs near the Clarion areas, its yields are little different than normal, but where it is near the Hayden areas, its yields are generally lower.

This is a good agricultural soil, or about equal to uneroded phases of Clarion silt loam in productivity. It has more complex and rolling relief, and parts of it are more subject to erosion than the Clarion. It has a lower content of organic matter, particularly in the eastern and southern parts of the county. Approximately 85 to 90 percent of the tillable land is used for small grains, intertilled crops, and tame hay. Owing to the large number of associated peat bogs and poorly drained areas from which wild-grass hay in many places is harvested, the acreage planted to tame hay is much less than it is on the Clarion soils. Barnyard manure is generally applied to land to be planted to corn. Any good rotation should include at least 2 or 3 years of a good sod crop. Suitable 4- and 5-year crop rotations are suggested in table 6.

Lester silt loam, undulating phase (LL).—This soil has a smoother surface than the associated rolling phase of Lester silt loam. Slopes do not exceed 7 percent. Erosion is negligible to slight. This phase has a slightly darker and thicker surface soil than the rolling phase, but its subsoil does not differ appreciably. The crops grown and management practices used on this phase are similar to those for the rolling phase, but this phase produces somewhat higher yields.

Lester silt loam, eroded undulating phase (LF).—This soil is similar to the undulating phase but has slopes of as much as 7 percent and has lost part of its surface soil through erosion. Soil losses probably resulted because this phase was farmed without concern for soil conserving measures.

Lester silt loam, eroded rolling phase (LE).—This phase resembles the rolling phase but has lost part of its original surface soil. It is associated with Hayden soils and other Lester soils. Slopes range from 7 to 13 percent but are mostly about 10 percent.

Remnants of the original surface soil have been incorporated with the upper part of the subsoil during tillage, so the surface soil now is 3 to 6 inches of grayish-brown heavy silt loam. The subsoil resembles that of the rolling phase.

This phase has lower productivity than the rolling phase and a narrower range in crop suitability. Erosion has removed much of the organic matter; consequently, the soil structure has been impaired and the capacity for absorbing and holding water has been reduced. A large acreage of this phase has been cleared, but some of it has reverted to permanent pasture. The acreage used for corn has declined and there has been a tendency to keep more of the soil in sod crops. Sound soil conserving practices must be employed to help restore this phase to its former productivity.

Lester silt loam, severely eroded rolling phase (LK).—This phase differs from the eroded rolling phase principally in having lost

most of its original surface soil. A few small gullies have formed. The two soils are about the same in degree of slope and are similar in subsoil characteristics. Areas of this eroded soil are scattered here and there, principally in cultivated fields, and are associated with other Lester soils.

Originally this soil was similar to Lester silt loam, rolling phase. It had the same crop suitability and, to a certain extent, the same management requirements. The management necessary for adequate control of runoff was not practiced, however, and the result was considerable loss of surface soil and decreased productivity. The productivity of this soil can be improved, for the supply of organic matter can be partly restored by good management practices, including the proper choice of crops.

Lester silt loam, hilly phase (LG).—This soil is similar to the rolling phase in profile characteristics but has stronger relief (13 to 20 percent slopes). It occurs in more hilly parts of the county where areas of Lester silt loam, rolling phase, predominate. Generally speaking, this phase has a somewhat lighter colored and thinner surface soil than the rolling phase, the result of less favorable moisture conditions and a correspondingly less luxuriant plant growth. The unfavorable moisture conditions are caused chiefly by loss of water through runoff.

Some areas of this hilly phase have been cleared and are now used for crops; others have been seeded to tame grasses and are in more or less permanent pastures; yet others are still forested. Crop yields average considerably lower than on Lester silt loam, rolling phase. Strong relief and high susceptibility to erosion make the management requirements of this soil exacting. In any management program the control of water is necessary to prevent further erosion and to conserve as much moisture as possible for crop plants.

Lester silt loam, eroded hilly phase (LD).—The principal differences between this phase and the hilly phase are the result of sheet erosion. This eroded phase has lost most of its original surface soil; the uneroded hilly phase retains nearly all of it. The two phases have about the same relief, or a slope range of 13 to 20 percent.

This eroded soil has some small gullies that are gradually becoming larger as cropping continues. It is associated with other Lester soils but occurs chiefly in the more strongly rolling parts of the county. Originally it was like the hilly phase; it had the same crop suitability and management requirement. Now, because improper use and management did not adequately control runoff, the productivity is lower, the rate of water absorption is less, and problems of soil management are greater. Since the organic-matter content has been materially lowered, the soil tilth has become impaired and the absorption of water has been further retarded. In addition, along with the destruction of soil structure, the soil has become difficult to till with machinery.

Much of this phase is used for permanent pasture, some is used for crops, and much is wooded. Strong relief and losses resulting from erosion make this soil unsuitable for crops. It is better suited to use for permanent pasture or woods. Crop yields are low and

uncertain. The pastures are generally poor, principally because the supply of moisture is not adequate. If this phase is cultivated, good management will be required. Good management will include application of commercial fertilizers and the addition of lime if soil tests show the need of it.

Le Sueur silty clay loam, nearly level phase (Lm).—This nearly level to slightly undulating soil is associated with the Clarion soils. It has developed from calcareous glacial till under the combined influence of grass and forest vegetation. Both external and internal drainage are medium to slow. The lower part of the subsoil, very heavy textured, firm, and compact, slows the movement of water through the soil.

The surface soil, averaging 14 inches in thickness, is brownish-black granular silty clay loam, friable when dry but somewhat sticky and plastic when wet. It is high in organic matter, slightly acid, and permeable to plant roots. The 6- to 8-inch subsurface soil is brownish-gray to weak-brown silty clay loam. It has a few dark streaks and splotches of material carried down from the overlying surface soil and is somewhat more acid than the surface soil. The upper subsoil, about 6 inches thick, is moderate-brown to strong-brown heavy silty clay loam of subangular blocky structure. This layer is medium acid, heavy textured, and plastic when moist. The lower subsoil, extending from a depth of 16 to 18 inches, is weak-yellow to dusky-yellow medium acid silty clay that shows mottlings of light brown to strong yellowish brown. A few iron concretions are embedded in the soil. The calcareous glacial till substratum is somewhat heavier in texture and occurs at lower depths than the substratum of the Hayden, Clarion, and Lester soils.

Practically all of this soil is tilled and cropped in about the same way as Clarion silt loam, undulating phase. It is high in organic matter and well suited to corn, small grains, and tame hay. In wet years small grains tend to lodge because of the high content of nitrogen in the soil. The high content of clay also hinders workability in wet years. Recommended crop rotations are given in table 6. The kinds and amounts of commercial fertilizers for various crops will depend on the results of soil tests.

Marsh (Ma).—This land type occupies shallow lakes and ponds that may become dry in years when precipitation is less than normal. Most areas remain wet all year. Cattails, rushes, sedges, and other water-tolerant plants grow luxuriantly and provide sanctuaries for wildfowl.

Mixed alluvium (Mb).—Mapped in this unit are some lowlands along the streams where the soils are mixed. Included are soils ranging from sand to clay in texture, from light to dark in color, and from poor to fair in drainage. Old stream channels have in many places cut the areas and made farming with machinery impossible. The land is flooded so frequently that it is not used as cropland, though in the drier years a few small suitable areas are cropped to corn. Most areas support a dense vegetation of trees and shrubs, and some are used for pasture.

Peat and muck (Pa).—Peat dominates in these organic soils. Most of the peat is formed from sedges, reeds, and grasses and occurs in poorly drained depressions which stay wet much of the year. In most bogs the peat is brown, fibrous, and spongy and has undergone little decomposition. Muck has undergone more decomposition than the peat and consists of a black or very dark-brown organic soil comparatively high in mineral matter. Like the peat it occurs in poorly drained depressions and unless drained is wet most of the year.

Peat and muck are suitable for various crops if properly drained and fertilized. Hay crops, generally a mixture of bromegrass, bluegrass, timothy, and clover, are the most promising. Reed canarygrass does well where the land is not adequately drained and subject to flooding or where the water table is close to the surface much of the time. Other crops, as oats, barley, and rye, often can be grown satisfactorily. Corn can be grown, but early autumn frosts make it an uncertain crop. Because peat is generally deficient in phosphate and potash, these nutrients must be added to make the soils productive. The supply of lime is adequate.

Steep land (Lester and Hayden soil materials) (Sa).—Most of this land type occurs as a narrow steeply sloping belt stretching along the Minnesota River between the broad flood plain and the undulating or rolling upland (pl. 3, *B*). Slopes are more than 30 percent. The areas consist mostly of Lester and Hayden soil materials developed from glacial till, though in some places these materials are mixed with silty material of wind origin.

The land is too steep and broken for agricultural use and supports a mixed hardwood forest, some of which is grazed. Frequently a farmstead occurs on this land, and part of it often is used as an exercising ground for livestock.

Storden silt loam, hilly phase (Sb).—This shallow soil has slopes of 13 to 20 percent and has developed under prairie vegetation from calcareous glacial till. Owing to hilly relief, much of the precipitation does not enter the soil but runs off and carries considerable surface soil with it. This hilly phase is closely associated with the Clarion and Lester soils but is more severely eroded.

The neutral or alkaline surface soil, 3 to 6 inches deep, is a friable brownish-gray granular silt loam. The 8- to 12-inch subsoil is light yellowish-brown to moderate grayish-brown silt loam, somewhat less granular than the surface soil. The subsoil is generally calcareous, though it is slightly acid where the surface soil is thicker. At 16 to 22 inches is the calcareous glacial till substratum, which is similar to that underlying the Clarion and Lester soils. The thickness of the surface soil and subsoil and the depth of the limy unweathered till vary considerably.

Much water is lost through surface runoff, so the soil dries out rapidly after rains. Droughtiness reduces yields materially in warm rainless periods during the growing season. Phosphate fertilizers are commonly required for satisfactory crop growth. This soil is used chiefly for pasture and hay crops, though small areas of it in fields of other soil types are farmed with those types and receive the same management.

Terrace escarpment (TA).—Narrow bodies of this steeply sloping land type occur between the nearly level terraces and the bottom lands or between one terrace and another. Mixed trees grow on many areas. Some areas are pastured.

Terril silt loam, gently sloping phase (TB).—Areas of this gently sloping soil occur along the Minnesota River. They are above the flood lands and below the narrow belt of steep broken land. Slopes range from 2 to 7 percent. The soil has developed from colluvium derived from the adjacent higher elevations. Both surface runoff and internal drainage are medium. Most of the soil originally had prairie vegetation, though scattered trees and grasses grew in some places.

The 14- to 18-inch surface soil is dusky-brown friable slightly acid granular silt loam. Small inclusions of sandy material are occasionally mixed with the finer particles. The upper part of the subsoil is 10 to 12 inches of weak-brown silt loam of subangular structure. This part is slightly more acid than the surface soil. The lower 10 to 12 inches of subsoil is slightly acid rather weakly defined light yellowish-brown silt loam. At 40 to 42 inches begins light yellowish-brown calcareous glacial till showing mottlings of gray.

Crop rotations suitable for Terril soils are given in table 6.

Terril silt loam, sloping phase (TC).—In distribution and association with other soils, this phase is similar to the gently sloping phase. It does not materially differ from the gently sloping phase in profile characteristics but it does have a thinner surface soil and a more variable assortment of different textured materials. Silts and clays predominate in both the surface soil and subsoil. This phase occupies upper slopes in those areas where materials were carried down from the adjacent higher uplands. Slopes range from 7 to 10 percent.

Much of this soil is cultivated, though the proportion is slightly less than that for the gently sloping phase. Management requirements and use possibilities are generally the same for both the gently sloping and sloping phases of Terril silt loam, except that more attention should be given to the control of runoff on this sloping phase.

Wadena loam, nearly level phase (WA).—This soil developed under prairie grasses and is underlain by limy sand and gravel at a depth of about 30 inches. Like Kasota silt loam it occupies a terrace position and has nearly level relief. Slopes do not exceed 3 percent. Both surface runoff and internal drainage are medium. The surface soil and subsoil are coarser textured than those of Kasota silt loam, and this soil therefore has a lower water-holding capacity and tends to be more droughty. In dry periods crops often suffer from lack of moisture, and yields are lower than on Kasota silt loam.

The 8- to 9-inch surface soil is brownish-black friable granular loam or heavy sandy loam. It contains a moderate quantity of organic matter and is generally neutral or slightly acid. The neutral to slightly acid subsoil, 10 to 12 inches deep, consists of light yellowish-brown friable loam of slightly subangular structure. This layer becomes appreciably coarser with increasing depth. The lower part of the subsoil is a light yellowish-brown mixture of sand and gravel. The subsoil is generally neutral, although occasionally it is slightly acid and in some places it is strongly alkaline and contains lime carbonates.

This soil is fairly productive when rainfall is ample and well distributed throughout the growing season. The principal crops are small grains, corn (pl. 3, *C*), and tame hay.

Wadena loam, undulating phase (Wc).—This phase differs from the nearly level phase chiefly in having slightly stronger relief (3 to 7 percent slopes). Except for having slightly more variable and probably slightly thinner soil layers, the profile of this phase is similar to that of the nearly level phase.

Like the nearly level phase, this phase occurs on the terraces along the Minnesota River. Practically all of it has been cleared and cultivated. The crops grown and the methods of soil management used are similar to those given for the nearly level phase (pl. 4, *A*).

Wadena loam, rolling phase (Wb).—This soil has a somewhat sandier surface soil and upper subsoil and thinner soil layers, but in other profile characteristics it is similar to the nearly level phase of Wadena loam. Its principal difference is in its stronger relief (slopes of 7 to 13 percent). In some places this phase is near the escarpment rising to the upland till plain.

Much of this fairly droughty soil has been cultivated. The crops grown are similar to those produced on the nearly level phase. Productivity is moderate, but the soil must be managed with caution to obtain maximum yields. Some of the areas with the sharpest slopes are severely eroded and gullies have formed. In some places the soil is blown by the wind. It is particularly susceptible to wind drifting early in spring before crops are seeded.

Webster and Le Sueur silty clay loams, nearly level phases (Wd).—The soil types in this mapping unit are so similar in profile characteristics and so alike in suitability for crops that separate mapping was not considered advisable. There is a slight difference in surface runoff and internal drainage. The Webster soils occupy the smoother positions where there is only slight runoff; most of the water must move through the soil and be removed through the underground drainage system. The Le Sueur soils occupy slightly higher positions and have a gentle slope, seldom more than 2 or 3 percent gradient, that allows more surface runoff. The Le Sueur soils therefore dry sooner after the spring thaw, which allows earlier working of the ground and preparation of a seedbed.

A description of Le Sueur silty clay loam, nearly level phase, is given on page 34.

The surface soil of Webster silty clay loam, nearly level phase, is about 12 inches thick. It is grayish-black to very dark-gray granular silty clay loam that is high in organic matter and generally slightly acid. In plowed fields the soil remains cloddy for comparatively long periods, particularly when dry. The subsurface soil, 6 to 7 inches thick, is dark-gray, mottled with yellowish brown, compact clay loam to heavy sandy clay. It is slightly more acid than the surface soil. In some places this subsurface layer has dark splotches and streaks where surface soil has washed into the cracks formed during dry periods. The upper 8 to 9 inches of the subsoil is slightly acid medium-gray compact heavy clay loam to sandy clay with mottlings of yellowish brown. This layer is weakly cemented when dry and plastic when wet. The aggregates in the dry subsoil are somewhat

subangular and irregular in size, and the structure is not always distinct. A few iron stains and concretions are frequently present in this layer. The lower 6 to 7 inches of the subsoil is highly mottled medium-gray and yellowish-brown sandy clay or clay that tends to form hard clods when disturbed. Numerous iron concretions and stains are also present. The calcareous glacial till substratum is at variable depths and is similar to that underlying the Le Sueur, Clarion, and Lester soils.

Some Webster areas have lime carbonate at the surface, whereas others are free of it. All areas, however, have a limy subsoil. Where an appreciable quantity of lime is present in the surface soil it often can be detected by a dull-gray or ashy-gray color in newly plowed fields late in summer or in fall when the soil is dry. In sections 34 and 35 of Lexington Township, sections 1 and 2 of Cordova Township, and section 5 of Cleveland Township, the gray color is particularly noticeable. Where lime is present in the surface soil, cover crops often respond well to potash fertilizers.

This soil complex is good agriculturally, even though it is somewhat imperfectly drained (pl. 4, *B*). Productivity can be increased greatly by tiling and draining, and many areas have been so improved. Small grains, corn, soybeans, and tame hay are the principal crops. The high organic-matter content occasionally causes small grains to lodge, particularly in seasons when growing conditions are most favorable. Under good management practices corn yields as high as 65 bushels per acre.

Rotations suitable for these soils are similar to those for Le Sueur silty clay loam, nearly level phase (see table 6). When alfalfa and sweetclover are grown on the Le Sueur soil, they tend to loosen the subsoil and thereby permit freer internal drainage and better root penetration for succeeding crops. The Webster soil is less suited to alfalfa than the Le Sueur because of the danger of winterkilling. Fertilizer treatments will depend on the results of soil tests.

Webster and Le Sueur silty clay loams, undulating phases (We).—These soils differ from the nearly level phases only in having slightly stronger relief, or slopes of 2 to 5 percent (pl. 4, *C*). They have slightly better surface runoff and can be worked somewhat earlier in spring and after heavy rains. In productivity and management practices these phases are about the same as the level phases. The same crops are grown, but more alfalfa is grown on these undulating phases.

USE AND MANAGEMENT OF SOILS IN LE SUEUR COUNTY

The objective of soil management is to keep the soil productive and obtain maximum sustained yields of suitable crops. Soils that differ widely must have different kinds of management if this twofold objective is to be achieved. Efficient crop production on a sustained basis requires accurate knowledge of the characteristics of individual soils and the close fitting of management practices to the needs shown by those characteristics.

In Le Sueur County the important individual management practices that together make up the soil management system are rotation of crops, liming, fertilization, use of green manure and barnyard manure,

drainage, and erosion control. These practices must be variously combined to achieve the best system of management for the individual soils. Suitable practices may be most conveniently given for the soils of the county by placing all the soils requiring about the same use and management in a group. For this county, 14 such groups were made after considering the properties of the soils that affect their use and management. The most important properties considered were texture of the surface soil and subsoil, natural drainage, slope, degree of erosion, and organic-matter content.

The soils of the 14 management groups are listed as follows:

GROUP 1. Well-drained dark-colored soils of the uplands on gentle slopes
- (CB) Clarion silt loam, eroded undulating phase
- (CD) Clarion silt loam, undulating phase
- (LF) Lester silt loam, eroded undulating phase
- (LL) Lester silt loam, undulating phase
- (TB) Terril silt loam, gently sloping phase

GROUP 2. Imperfectly drained dark-colored soils
- (LM) Le Sueur silty clay loam, nearly level phase
- (WD) Webster and Le Sueur silty clay loams, nearly level phases
- (WE) Webster and Le Sueur silty clay loams, undulating phases

GROUP 3. Poorly drained dark-colored soils
- (GA) Glencoe and Webster silty clay loams
- (GB) Glencoe silt loam

GROUP 4. Well-drained dark-colored soils of the uplands on moderate slopes
- (CA) Clarion silt loam, eroded rolling phase
- (CC) Clarion silt loam, rolling phase
- (LE) Lester silt loam, eroded rolling phase
- (LH) Lester silt loam, rolling phase
- (LK) Lester silt loam, severely eroded rolling phase
- (TC) Terril silt loam, sloping phase

GROUP 5. Well-drained light-colored silt loams and loams on gentle slopes
- (HB) Hayden silt loam and loam, eroded undulating phases
- (HF) Hayden silt loam and loam, undulating phases

GROUP 6. Well-drained light-colored silt loams and loams on moderate slopes
- (HD) Hayden silt loam and loam, rolling phases
- (HE) Hayden silt loam and loam, severely eroded rolling phases

GROUP 7. Well-drained dark-colored soils of terraces on gentle to moderate slopes
- (EA) Estherville sandy loam
- (HG) Hubbard fine sandy loam, eroded rolling phase
- (HH) Hubbard fine sandy loam, eroded undulating phase
- (HL) Hubbard fine sandy loam, nearly level phase
- (KA) Kasota silt loam
- (WA) Wadena loam, nearly level phase
- (WB) Wadena loam, rolling phase
- (WC) Wadena loam, undulating phase

GROUP 8. Well-drained sandy soils on gentle to moderate slopes
- (BB) Burnsville sandy loam, eroded rolling phase
- (BC) Burnsville sandy loam, eroded undulating phase
- (BE) Burnsville sandy loam, rolling phase

GROUP 9. Intermingled silt loams and sandy loams on gentle to moderate slopes
- (LA) Lester-Lakeville complex, eroded rolling phases
- (LC) Lester-Lakeville complex, undulating and rolling phases

GROUP 10. Shallow soils over bedrock
- (CE) Copas loam, nearly level phase
- (CF) Copas loam, undulating phase

GROUP 11. Hilly to steep soils
- (BD) Burnsville sandy loam, hilly phase
- (HA) Hayden silt loam and loam, eroded hilly phases
- (HC) Hayden silt loam and loam, hilly phases
- (HK) Hubbard fine sandy loam, moderately steep phase
- (LB) Lester-Lakeville complex, hilly phases

(LD) Lester silt loam, eroded hilly phase
(LG) Lester silt loam, hilly phase
(SB) Storden silt loam, hilly phase

GROUP 12. Soils of the flood plains
(DA) Dorchester silt loam
(MB) Mixed alluvium

GROUP 13. Organic soils
(PA) Peat and muck

GROUP 14. Miscellaneous nonarable land types
(BA) Beach sand
(GP) Gravel pits
Limestone quarry [1]
(MA) Marsh
(SA) Steep land (Lester and Hayden soil materials)
(TA) Terrace escarpment

[1] See Conventional Signs on soil map for symbol.

Uses, crop rotations, and supplemental management practices are suggested for each management group in table 6. The problems of management are similar for all soils in one group, but they may be more severe for one soil of that group than for another. The management groups in table 6 correspond to the color groupings in the legend on the soil map; consequently, all soils shown in one color on the map require about the same use and management.

CROP ROTATIONS AND SUPPLEMENTAL PRACTICES

A necessary part of soil management is the selection of a crop rotation or type of land use suited to the soil. Suggested crop rotations or types of land use and supplemental practices [5] are shown in table 6 for each of the 14 management groups. The supplemental practices recommended for a given management group are to be used, as needed, with the rotations suggested for that group.

In Le Sueur County, the key crop in the rotation for maintenance of soil productivity is the legume-grass meadow. The legume in the meadow mixture, if inoculated, fixes nitrogen from the atmosphere and thus helps maintain the supply of this important nutrient in the soil. Also, when grass-legume meadows are plowed, the residual top growth and the extensive root system are added to the soil and help maintain its supply of organic matter. Organic matter plays an important role in promoting desirable soil structure, which in turn increases the permeability of the soil and its resistance to erosion.

Soils with smoother slopes, as those in management group 1, are not so subject to erosion and usually can be kept highly productive with a lower proportion of grasses and legumes than is needed for steeper soils, as those in group 11.

FERTILIZER, LIME, AND MANURE

Soil tests should be made to determine the need for lime and commercial fertilizer. Consult your county agricultural agent for information on how to collect soil samples. Send the samples to the

[5] Supplemental practices are those practices used with crop rotations mainly to provide additional control of runoff and attendant soil loss or to improve drainage. See the section on Water Control on the Land for additional information. Pasture renovation is also a very important supplemental practice for certain groups.

TABLE 6.—*Suggested use and management for the soils of Le Sueur*

[Rotations suggested in this table are those considered necessary to obtain the yields listed in tabl of livestock farming common in Le Sueur County. G=any small grain such as oats, barley, or rotation pasture; C=corn or other adapted intertilled crop such as soybeans, sugar beets, seeded to sweet clover, the clover to be used as green manure.]

Map symbol	Management group and soil	Suitable uses [1]	Suggested r
	1. Well-drained dark-colored soils of the uplands on gentle slopes:		
	Clarion silt loam:		
CB	Eroded undulating phase	Corn, alfalfa, soybeans, canning crops, small grains, clover, flax, and grasses.	3-year: G–H–C
CD	Undulating phase		4-year: G–H–C–G–H–H–C
	Lester silt loam:		
LF	Eroded undulating phase		5-year: G–H–H-
LL	Undulating phase		6-year: G–H–H–(SwCl)–C
TB	Terril silt loam, gently sloping phase		
	2. Imperfectly drained dark-colored soils:		
LM	Le Sueur silty clay loam, nearly level phase.	Corn, alfalfa, flax, clover, soybeans, canning crops, small grains, sugar beets, and grasses.	2-year: G(SwCl)
	Webster and Le Sueur silty clay loams:		3-year: G–H–C
WD	Nearly level phases		4-year: G–H–C–G–H–H–C
WE	Undulating phases		5-year: G–H–H–G–G–H–H–C
	3. Poorly drained dark-colored soils:		
GA	Glencoe and Webster silty clay loams	Corn, clover, soybeans, grasses, and canning crops.	2-year: G(SwCl)
GB	Glencoe silt loam		3-year: G–H–C
			4-year: G–H–C
	4. Well-drained dark-colored soils of the uplands on moderate slopes:		
	Clarion silt loam:		
CA	Eroded rolling phase	Corn, alfalfa, small grains, clover, and grasses.	4-year: G–H–H–H–H
CC	Rolling phase		
	Lester silt loam:		
LE	Eroded rolling phase		6-year: G–(SwCl)–C
LH	Rolling phase		
LK	Severely eroded rolling phase		
TC	Terril silt loam, sloping phase		

See footnotes at end of table.

TABLE 6.—*Suggested use and management for the soils of Le Sueur Coun*

Map symbol	Management group and soil	Suitable uses [1]	Suggested ro
	5. Well-drained light-colored silt loams and loams on gentle slopes:		
	Hayden silt loam and loam:		
HB	Eroded undulating phases	Corn, alfalfa, small grains, clover, and grasses.	3-year: G-H-C 4-year: G-H-H-
HF	Undulating phases		6-year: G-(SwCl)-C
	6. Well-drained light-colored silt loams and loams on moderate slopes:		
	Hayden silt loam and loam:		
HD	Rolling phases	Corn, alfalfa, small grains, clover, and grasses.	4-year: G-H-G-H-H-H
HE	Severely eroded rolling phases		5-year: G-H-H-
	7. Well-drained dark-colored soils of terraces on gentle to moderate slopes:		
EA	Estherville sandy loam	Corn, alfalfa, small grains, clover, soybeans, grasses, and canning crops.	3-year: G-G-H 4-year: G-H-H- G-G-H-C or G-
	Hubbard fine sandy loam:		
HG	Eroded rolling phase		
HH	Eroded undulating phase		
HL	Nearly level phase		
KA	Kasota silt loam		
	Wadena loam:		
WA	Nearly level phase		
WB	Rolling phase		
WC	Undulating phase		
	8. Well-drained sandy soils on gentle to moderate slopes:		
	Burnsville sandy loam:		
BB	Eroded rolling phase	Corn, alfalfa, small grains, clover, and grasses.	4-year: G-H-H-H-H 5-year: G-H-H- Permanent pastu
BC	Eroded undulating phase		
BE	Rolling phase		
	9. Intermingled silt loams and sandy loams on gentle to moderate slopes:		
	Lester-Lakeville complex:		
LA	Eroded rolling phases	Small grains, clover, grasses, and alfalfa.	4-year: G-H-H- Permanent pastu Permanent hay.
LC	Undulating and rolling phases		

	10. Shallow soils over bedrock:		
	Copas loam: [2]		
CE	Nearly level phase	Pasture or hay.	Permanent pastu
CF	Undulating phase		Permanent hay.
	11. Hilly to steep soils:		
BD	Burnsville sandy loam, hilly phase	Small grains, alfalfa, clover, grasses and trees.	
	Hayden silt loam and loam:		
HA	Eroded hilly phases		
HC	Hilly phases		
HK	Hubbard fine sandy loam, moderately steep phase.		4-year: G–H–H-
LB	Lester-Lakeville complex, hilly phases		Permanent pastu
	Lester silt loam:		Permanent hay.
LD	Eroded hilly phase		
LG	Hilly phase		
SB	Storden silt loam, hilly phase		
	12. Soils of the flood plains:		
DA	Dorchester silt loam	Corn, clover, grasses, soybeans, sugar beets, and canning crops.	3-year: G(SwCl)
MB	Mixed alluvium		4-year: G–H–C-
			Permanent pastu
	13. Organic soils:		
PA	Peat and muck	Corn, corn silage, grass hay and pasture, soybeans, and truck crops.	3-year: G–H–C
			4-year: G–H–C-
			5-year: G–H–H-
			Permanent pastu
	14. Miscellaneous nonarable land types:		
BA	Beach sand	Not suited to agricultural crops; some areas used for trees or pasture.	
GP	Gravel pits		
	Limestone quarry [3]		
MA	Marsh		
SA	Steep land (Lester and Hayden soil materials).		
TA	Terrace escarpment		

[1] Individual soils in any one group may vary in suitability for the crops listed. See table 7; b
ability of a soil for specified crops.

[2] Small areas of Copas soils may be suited to rotations of corn or small grains.

[3] See Conventional Signs on soil map for symbol.

Soil Testing Laboratory, University Farm, St. Paul 1, Minnesota, for testing. Fields should be tested well in advance of fertilization, but not more than 2 years before the time of application.

Conserve barnyard manure and return it to the land. It is a source of needed plant nutrients and provides organic matter, which improves the tilth and water-holding capacity of the soil.

CROP YIELDS TO BE EXPECTED

Estimated average acre yields of principal crops that may be expected over a period of years on the soils of Le Sueur County are listed in table 7. It is assumed that one of the crop rotations suggested in table 6, together with appropriate supplemental practices, will be followed; that lime and fertilizer will be used according to recommendations based on soil tests; and that manure will be wisely conserved and applied before the crop of highest value in the rotation.

Taken into account in arriving at the yield estimates were the principal factors affecting productivity—climate, characteristics of the soil, and management. Records on crop yields over a long period of time were used, where available, as guides in making the yield estimates. Primarily, however, the estimates are based on interviews with farmers, members of the staff of the Minnesota Agricultural Experiment Station, and others familiar with the agriculture of the county.

WATER CONTROL ON THE LAND

Control of water on the land deals with (1) controlling runoff so as to prevent sheet and gully erosion and the consequent lowering of the soil moisture retained for plant growth and (2) removing excess water where natural drainage is not adequate to provide suitable growing conditions for plants. Irrigation and flood control practices are not followed in this county. The bottom land soils along the Minnesota River are subject to periodic floodings which often delay tillage operations in spring. Cleveland Township would be greatly improved by tile drainage.

CONTROL OF RUNOFF

Runoff refers to the water, falling in the form of rain and resulting from melting snow, that runs off the land. In controlling runoff, various practices are employed that tend to hold the water where it falls, thus conserving it for plant growth. When runoff is excessive, not only is the water lost but valuable surface soil is also removed.

Nearly all land that is cropped, particularly where corn and other intertilled crops are grown, is subject to soil losses from runoff. Pasture land that is overgrazed and forested areas stripped of timber are also seriously affected.

The need for control of runoff varies in different parts of the county. The upland areas of the Clarion and Lester soils in the north-central part and the terrace areas have little runoff. Here the slopes are gentle with low gradient, and the soils have more organic matter and a favorable structure that allows the water to be readily absorbed. Most farms in other parts of the county need some protection from runoff. Along the eastern and southern parts of the county, where the land is more rolling and the slopes are abrupt, there is a lower content of organic matter in the surface soil and runoff is more severe.

TABLE 7.—*Estimated average acre yields of principal crops to be expected over a per*
County, Minn.

[It is assumed that the soils will be cropped with rotations given in table 6; that lime and ferti
soil tests; that manure will be wisely used; and that suitable supplemental practices, as draina
Yields are estimated *average* yields for all areas of a given soil; farmers using superior manage
timing farming operations may be able to obtain yields higher than those given in this table.
is not considered suitable for crop specified.]

Map symbol	Soil	Corn	Corn silage	Soybeans	Oats	Barley
		Bu.	*Tons*	*Bu.*	*Bu.*	*Bu.*
BA	Beach sand					
	Burnsville sandy loam:					
BC	Eroded undulating phase	20	4	8	25	14
BE	Rolling phase	20	4	7	25	14
BB	Eroded rolling phase	15	3	5	20	12
BD	Hilly phase					
	Clarion silt loam:					
CD	Undulating phase	60	12	22	55	38
CB	Eroded undulating phase	53	10	20	50	35
CC	Rolling phase	53	10	17	50	35
CA	Eroded rolling phase	47	8	14	40	26
	Copas loam:					
CE	Nearly level phase	32	6	10	35	20
CF	Undulating phase	28	6	10	30	18
DA	Dorchester silt loam	62	13	22	48	30
EA	Estherville sandy loam	20	3	6	22	13
GB	Glencoe silt loam	55	14	24	50	34
GA	Glencoe and Webster silty clay loams	60	13	24	55	35
GP	Gravel pits					

See footnotes at end of table.

TABLE 7.—*Estimated average acre yields of principal crops to be expected over a peri*
County, Minn.—Continued

Map symbol	Soil	Corn	Corn silage	Soybeans	Oats	Barley
		Bu.	*Tons*	*Bu.*	*Bu.*	*Bu.*
	Hayden silt loam and loam:					
HF	Undulating phases	50	9	15	45	30
HB	Eroded undulating phases	40	7	12	40	25
HD	Rolling phases	40	7	10	40	25
HE	Severely eroded rolling phases	25	5	8	30	18
HC	Hilly phases					
HA	Eroded hilly phases					
	Hubbard fine sandy loam:					
HL	Nearly level phase	35	6	10	35	18
HH	Eroded undulating phase	25	5	8	20	14
HG	Eroded rolling phase	20	3	6	20	12
HK	Moderately steep phase					
KA	Kasota silt loam	55	10	20	50	35
	Lester-Lakeville complex:					
LC	Undulating and rolling phases	45	8	12	40	25
LA	Eroded rolling phases	35	6	8	30	20
LB	Hilly phases					
	Lester silt loam:					
LL	Undulating phase	60	12	22	55	38
LF	Eroded undulating phase	53	10	20	50	50
LH	Rolling phase	52	10	18	50	35
LE	Eroded rolling phase	47	8	15	40	25
LK	Severely eroded rolling phase	40	6	10	30	20
LG	Hilly phase				30	20
LD	Eroded hilly phase				25	17

LM	Le Sueur silty clay loam, nearly level phase	65	12	23	55	3
	Limestone quarry					
MA	Marsh					
MB	Mixed alluvium					
PA	Peat and muck	40	13	18	35	2
SA	Steep land (Lester and Hayden soil materials)					
SB	Storden silt loam, hilly phase				30	2
TA	Terrace escarpment					
	Terril silt loam:					
TB	Gently sloping phase	60	12	23	55	3
TC	Sloping phase	50	10	20	50	3
	Wadena loam:					
WA	Nearly level phase	40	7	14	40	2
WC	Undulating phase	35	6	12	35	2
WB	Rolling phase	25	3	6	25	1
	Webster and Le Sueur silty clay loams:					
WD	Nearly level phases	65	12	23	50	3
WE	Undulating phases	65	12	23	50	3

[1] See corresponding group in table 6.

[2] Cow-acre-days, used to express the carrying capacity of pasture land, is the number of da
animal unit without injury to the pasture and without supplemental feeding while on pasture.

[3] Permanent pasture.

Tillage operations are more up-and-down hill than on the contour and tend to increase runoff. Around Waterville, a large acreage is used for hybrid seed corn production. Using the same land for corn for long periods permits rapid destruction of the organic matter, and as a result the soil structure is impaired and runoff is increased.

Many beneficial results are achieved when runoff is controlled. Moisture is conserved and a more uniform and adequate supply is held available for plant growth. The surface soil, a storehouse for available plant nutrients, is saved and kept in place. Higher crop yields are a direct result. The organic-matter content of the soil is conserved, which allows for more biological activity. As a result of the biological activity more plant nutrients are made available in the soil. The general tilth of the soil is improved, and tillage operations are therefore easier to perform.

Fortunately, excessive runoff can be controlled by simple farm practices. This involves, first of all, proper land use. The foundation for all crop enterprises should be a good crop rotation. Minnesota Agricultural Extension Bulletin 254 gives general information about a fertility program suitable for the soils of this county.

Various crops have different feeding and nutritive habits. Intertilled crops, such as corn and soybeans, tend to keep the soil open, thus reducing the organic-matter content very rapidly. A good 4- or 5-year rotation would consist of a cultivated crop, a grain crop, and a hay crop such as alfalfa or clover. The hay crop is important, for it helps build up the organic matter and keeps the ground covered. The use of barnyard manure and commercial fertilizers in combination with a good rotation is also important. These amendments build up the fertility and promote vigorous and healthy plant growth. Contour tillage is another practice that can be employed. It is important for intertilled crops such as corn, since many gullies have been started by water collecting and running down furrows made by farm implements. Natural drainageways should be left in permanent sod to prevent gullies from starting in cultivated fields.

Much of the excess runoff and accompanying soil loss has resulted from improper land use. Land with very steep slopes should be kept in permanent forest. Land with less pronounced slopes should be in permanent pasture, and the grazing should be controlled to permit a good sod. Land with still less slope should be kept in permanent hay as much as possible (plowed only as often as necessary for reseeding). Grain crops should be confined to gently sloping land where runoff is not excessive. Corn and all intertilled crops should be kept on nearly level to gently sloping land. Terracing and contour strip cropping are also employed to reduce and control runoff.

DRAINAGE

More adequate drainage is needed in some areas of the Webster soils. Large nearly level upland plains in Cordova, Lexington, Sharon, and Cleveland Townships would be greatly improved by tile drainage. In years of excessive moisture, tillage is greatly delayed in spring. Some areas of Le Sueur silty clay loam also have restricted internal drainage and are difficult to work when wet.

Considerable drainage has already been done in these areas by individual farmers, but one of the chief difficulties in enlarging the

drainage system is lack of adequate outlets. The Webster and Le Sueur soils are fertile, and when artificially drained their productivity is greatly increased, particularly for corn. Frequently in the Webster areas, there are small depressions where soluble salts accumulate and injure plant growth. These areas, although small, are in places benefited by the drainage. Some Peat and muck areas have been drained and are producing tame hay and occasionally grain. The crops that can be satisfactorily grown on Peat and muck are limited, owing to the hazards connected with farming these soils.

MORPHOLOGY, GENESIS, AND CLASSIFICATION OF SOILS

Five main factors contribute to the formation of soil—climate, vegetation, parent material, relief, and time. Perhaps the most dynamic of these are climate and vegetation, which work upon the parent material over a long period of time to produce soil. Relief, or lay of the land, determines to large extent the quantity of water that enters the soil.

Because of differences in the five main factors, soils may be well developed, poorly developed, or at various stages of development between these extremes. Soils like the Clarion are moderately developed. They are the result of the five factors of soil formation, all having their weighted effect upon soil formation. The Storden soils are developed where the surface relief is a prominent factor in development and have more poorly developed profiles than the Clarion. The soils formed from alluvial material, such as the Dorchester, show the effect of the shorter period of time in their development. Here frequent floods have been responsible for deposition of fresh material, and time has only slightly affected the development of the soil.

Le Sueur County is in the Central Lowland province of the Western Young Drift section of the Interior Plains.[6] It lies in a glaciated region characterized by young glaciated plains, moraines, lakes, and lacustrine plains. The county is covered by young gray drift of the Mankato age. The glacial till, as it does almost everywhere, varies in different parts of the county. In the Clarion and the Lester areas the till is heavy and resembles one of older age than the Mankato, but information as to its origin has not yet been determined. The till in the morainic area in the southern part of the county has inclusions of sand and gravel. Particularly around the lakes, layers of stratified gravel and sands are embedded in the till. In the Burnsville soil areas the loose till consists of sandy gravelly highly calcareous material. In general the unstratified glacial drift in the county is light yellowish-brown calcareous clay loam or sandy clay slightly mottled with weak yellow and gray. It is high in calcium and magnesium carbonates and effervesces freely with hydrochloric acid. It is composed of material derived mostly from limestone and calcareous shales.

The county has a midcontinental type of climate with wide variations in temperatures from summer to winter. The soil generally

[6] FENNEMAN, N. M. PHYSIOGRAPHY OF EASTERN UNITED STATES. 714 pp., illus. 1938. New York and London.

remains frozen 4 to 5 months. The depth to which frost penetrates depends mostly on the quantity of snow received late in fall or early in winter. Snow is somewhat beneficial, since for a time there is no water erosion and the denitrification processes are more or less inactive. During the time snow is on the ground, the soil-forming processes are dormant, though the physical processes of alternate freezing and thawing are at times active.

The relief of the county varies from nearly level on the bottom lands and terraces to strongly rolling and hilly in the morainic part of the upland. The variations in relief have affected drainage and soil development. The bottom land soils have slow surface runoff and internal drainage. They are subject to frequent floods and thus often receive additional material from the silt-laden waters. The terrace soils, underlain by sand and gravel, have medium to rapid drainage. The Hubbard soils, for example, are coarse textured and therefore have rapid internal drainage. The uplands occupied by the Clarion and Lester soils have medium surface runoff and internal drainage, and these are among the best developed soils in the county. The Webster and Glencoe soils have restricted internal drainage and a mottled B horizon. In some areas these soils have a water table 3 to 4 feet from the surface. In the morainic areas where surface runoff is rapid there is a considerable loss of water by runoff. In such places the other soil-forming factors are subordinated to the relief and excessive drainage.

The two types of vegetation—forest and prairie—that originally prevailed in the county have influenced soil development. At the time of settlement, the southern part of the Big Woods area in Minnesota covered most of Le Sueur County. Included in this timbered area were a few prairie areas where tall grasses flourished. The line separating the prairie and forest areas probably was never stationary. It no doubt shifted back and forth, creating a so-called ecological tension zone between the two types of vegetation. Because of this, the prairie soils in this part of the county are not so dark nor so highly developed as a Prairie soil. Most of the soils in the county are more or less transitional in character. They are medium dark at the immediate surface, showing the influence of prairie grasses, but have a layer below that shows the gray podzolized horizon characteristic of forest soils. Along the eastern and southern sides of the county, which always were wooded, Gray Brown Podzolic soils are found that have a pronounced A_2 horizon.

CLASSIFICATION OF SOILS

The soils of the United States are grouped into several categories based on their characteristics. In this scheme soils are classified into orders, suborders, great soil groups, families, series, types, and phases. In Le Sueur County all three orders—zonal, intrazonal, and azonal—are represented. The soil series of the county are classified by higher categories in table 8.

ZONAL SOILS

Zonal soils have well-defined characteristics that reflect the influence of climate and vegetation. In this order two great soil groups are recognized in the county—Prairie soils and Gray-Brown Podzolic soils.

TABLE 8.—*Classification of the soil series of Le Sueur County, Minn.,*

Great soil group and soil series	Parent material	Relief
ZONAL SOILS		
Prairie soils:		
Clarion	Calcareous till	Undulating to rolling
Le Sueur	do	Nearly level to undulating
Lester [2]	do	Undulating to hilly
Lakeville	Calcareous till (loose)	do
Terril	Colluvium over calcareous till	Gently sloping to sloping
Estherville	Glacial outwash	Nearly level to gently undu
Hubbard	do	Nearly level to moderately
Kasota	do	Nearly level to very gently
Wadena	do	Nearly level to rolling
Copas	Glacial outwash (shallow over bedrock).	Nearly level to undulating
Gray-Brown Podzolic soils:		
Hayden	Calcareous till	Undulating to hilly
Burnsville	Calcareous till (loose)	do
INTRAZONAL SOILS		
Humic Gley:		
Webster	Calcareous till	Nearly level to undulating
Glencoe	do	Nearly level (depressional)
AZONAL SOILS		
Alluvial soils:		
Dorchester	Recent alluvium	Nearly level
Regosols:		
Storden	Calcareous	Hilly

[1] Soil classification in this report is according to the scheme outlined in Soils and Men, Yearb Soil Sci. 67 (2) : 191 pp., illus. 1949.

[2] Transitional (degraded Prairie).

The Clarion, Le Sueur, Lakeville, Terril, Estherville, Hubbard, Kasota, Wadena, and Copas series are Prairie soils. The Lester soils occupy a transitional zone between the grassland and forested soils and are known as degraded Prairie soils. The Hayden and Burnsville are Gray-Brown Podzolic soils.

Clarion silt loam, undulating phase, is representative of the well-drained Prairie soils of the uplands that develop from glacial till under grass vegetation. A profile description of this soil follows:

A 0 to 13 inches, dark brownish-black to black granular heavy silt loam, the lower part of which is browner and slightly more compact than the upper; many grass roots; slightly acid.

B_1 13 to 20 inches, brownish-black to brownish-gray heavy silt loam to silty clay loam that is slightly compact and has subangular blocky structure; contains tongues and streaks of dark material carried down from the A horizon; slightly acid.

B_2 20 to 30 inches, dark yellowish-brown moderately compact silty clay loam with subangular structure; aggregates break down easily upon slight pressure; moderately acid.

C_1 30 to 36 inches, moderate yellowish-brown moderately compact silty clay loam having a weak angular structure; more friable than soil of B horizon; nearly neutral.

C_2 36 to 48 inches, light yellowish-brown calcareous glacial till; carbonates present at about 40 inches.

The undulating to hilly Hayden soils, representative of the Gray-Brown Podzolic soils, have developed from glacial till similar to that of the Clarion but under forest vegetation. They are formed by podzolization and have a well-defined profile. The B horizon is particularly well developed. Following is a profile description of Hayden silt loam and loam, undulating phases:

A_{00} About 2 inches of leaf litter, duff, and leafmold.

A_1 0 to 1 inch, dark-brown to black organic matter mixed with a small quantity of mineral soil; slightly acid.

A_2 1 to 7 inches, light brownish-gray mellow floury loam with a weak platy structure; many roots present; moderately acid.

A_3 7 to 10 inches, light yellowish-brown to very pale-brown weak platy mellow floury silt loam; slightly more compact than the layer above; moderately acid.

B_1 10 to 24 inches, moderate yellowish-brown compact silty clay loam with an angular nut structure; aggregates are coated with material from the layers above; strongly acid.

B_2 24 to 34 inches, yellowish-brown, streaked with gray and dark brown, clay loam of compact blocky structure; some gray coating on the aggregates; very hard and indurated when dry and sticky when wet; strongly acid.

C 34 to 40 inches, yellowish-brown and grayish-brown calcareous glacial till with some sand pockets and a few iron concretions; lime carbonate present at about 36 inches.

INTRAZONAL SOILS

Intrazonal soils are those that reflect the dominance of some local factor, such as relief, parent material, or age, over the influence of climate and vegetation. The Humic Gley group, represented by the Webster and Glencoe soils, is in this order. The Webster soils are semihydromorphic, and the Glencoe soils hydromorphic.

Profile description of Webster silty clay loam:

A 0 to 13 inches, black to brownish-black heavy granular silty clay loam containing many grass roots; becomes grayer in the lower part; slightly acid.

B_1 13 to 21 inches, mottled dark-gray and yellowish-brown compact clay loam to heavy sandy clay; a few iron stains and iron concretions present; strongly acid.

B_2 21 to 29 inches, medium-gray, mottled with strong yellowish-brown, compact heavy clay loam to sandy clay; hard when dry and moderately plastic when wet; numerous iron stains and concretions; slightly acid.

C_1 29 to 35 inches, medium-gray clay highly mottled with yellowish brown; contains iron concretions and stains; moderately to strongly plastic when wet; slightly acid.

C_2 35 to 48 inches, medium-gray glacial till with mottlings of yellowish brown; iron stains and lime concretions present; lime carbonate at about 40 inches.

AZONAL SOILS

Azonal soils are those with no well-developed characteristics. The Alluvial and Regosol groups are in this order and are represented by the Dorchester and Storden series, respectively.

The immature Dorchester soil occurs on bottom lands subject to occasional flooding. It is an Alluvial soil and has no definite profile development. The reaction is slightly acid to alkaline, often calcareous on the surface. The Storden soil, a Regosol, is found on slopes greater than 12 percent. Recent limy parent material is in many places within 6 inches or less of the surface.

SOIL SURVEY METHODS AND DEFINITIONS

Soil surveying consists of examining, classifying, and mapping of soils in the field. The soil scientist walks over the area at frequent intervals and bores into the soil with an auger or digs holes with a spade. Each such boring or hole shows the soil to consist of several distinctly different layers, called horizons, which collectively are known as the soil profile. Each of these layers is studied carefully for the things about it that affect plant growth.

The color of each layer is noted. There is usually a relationship between the darkness of the color of the topmost layer of soil and its content of organic matter; streaks and spots of gray, yellow, and brown in lower layers generally indicate poor drainage and poor aeration.

Texture—the content of sand, silt, and clay in each layer—is determined by the feel of the soil when rubbed between the fingers and is checked by mechanical analyses in the laboratory. Texture determines to a considerable extent the quantity of moisture the soil will hold available to plants, whether plant nutrients or fertilizers will be held by the soil in forms available to plants or will be leached out, and the difficulty or ease of cultivating the soil.

Soil structure, or granulation, and the number of pores or open spaces between soil particles determine the permeability or perviousness of the soil, and consequently, the ease with which plant roots and water enter the soil.

Consistence, or the tendency of the soil to crumble or to stick together, determines the degree of difficulty that will be encountered in keeping the soil open and porous under cultivation. Consistence covers such soil characteristics as hardness, friability, plasticity, stickiness, compactness, toughness, and cementation.

Surface soil ordinarily refers to the surface layer, which is usually 5 to 10 inches thick. The layer just below the surface soil is the subsoil; the layer beneath the subsoil, the substratum.

The kind of rocks and the soil parent material that develops from these rocks affect the quantity and kind of plant nutrients found in the soil. Simple chemical tests are made to show the degree of acidity of the soil, and the depth to bedrock or to compact layers is determined. The quantity of gravel or rocks that may interfere with cultivation, the steepness and kind of slope, the quantity of soil lost by erosion, and other external features are observed.

On the basis of all these characteristics, soil areas much alike in the kind, thickness and arrangement of layers are mapped as one soil type. Some soil types are separated into two or more phases. For example, if a soil has slopes ranging from 2 to 13 percent, the type may be mapped in two phases, an undulating phase (2 to 7 percent slopes) and a rolling phase (7 to 13 percent slopes). Phases may also be designated on the different degrees of erosion, such as an uneroded phase, an eroded phase, or a severely eroded phase. A soil type is broken into phases primarily because of differences in the soil other than those of kind, thickness, and arrangement of layers. The slope of a soil, the frequency of outcropping bedrock, the extent of its erosion, or the artificial drainage used on the soil, for example, are characteristics that might cause a soil type to be divided into phases.

Two or more soil types may have similar profiles; that is, the soil layers may be nearly the same, except that the texture, especially of the surface layer, may differ. As long as the other characteristics of the soil layers are similar, these soils are considered to belong in the same soil series. A soil series therefore consists of all soil types, whether the number be only one or several, that are, except for texture—particularly the texture of the surface layer—about the same in kind, thickness, and arrangement of layers.

The name of a place near where a soil series was first found is chosen as the name of the series. Thus, Hayden is the name of a well-drained light-colored wooded soil series on glacial deposits rich in lime. This series was first mapped in Hennepin County, Minn. In Le Sueur County, two types of the Hayden series are found—Hayden loam and Hayden silt loam. These differ in the texture of the surface soil, as their names show. Then, if there are different kinds of slopes within areas of the Hayden loam or Hayden silt loam these differences would be known as phases. For example, areas of Hayden silt loam with slopes ranging from 0 to 7 percent are designated as Hayden silt loam, undulating phase, and areas with slopes ranging between 7 and 13 percent are Hayden silt loam, rolling phase.

When small areas of two or more kinds of soil are so intricately mixed that they cannot be shown separately on a map of the scale used, they are mapped together, and the areas of the mixture are called a soil complex. Lester-Lakeville complex is a mixture of Lester silt loam and Lakeville loam and fine sandy loam in Le Sueur County.

Areas that have little true soil are known as miscellaneous land types and are not designated with series and type names but are given descriptive names, as Mixed alluvium, Steep land (Lester and Hayden soil materials), and Beach sand.

The soil type or, where the soil type is subdivided, the soil phase, is the mapping unit in soil surveys. It is the unit or the kind of soil that is most nearly uniform and has the narrowest range of characteristics. For this reason land use and soil management practices can be more definitely specified for it than for broader groups of soils that contain more variation. One can say, for example, that soils of the Clarion series are well suited to general farm crops. More specifically it can be stated that Clarion silt loam, undulating phase, is well drained, not seriously affected by erosion, and is highly productive under good management; whereas, in contrast, Clarion silt loam, eroded rolling phase, has a high erosion hazard and is not so productive.

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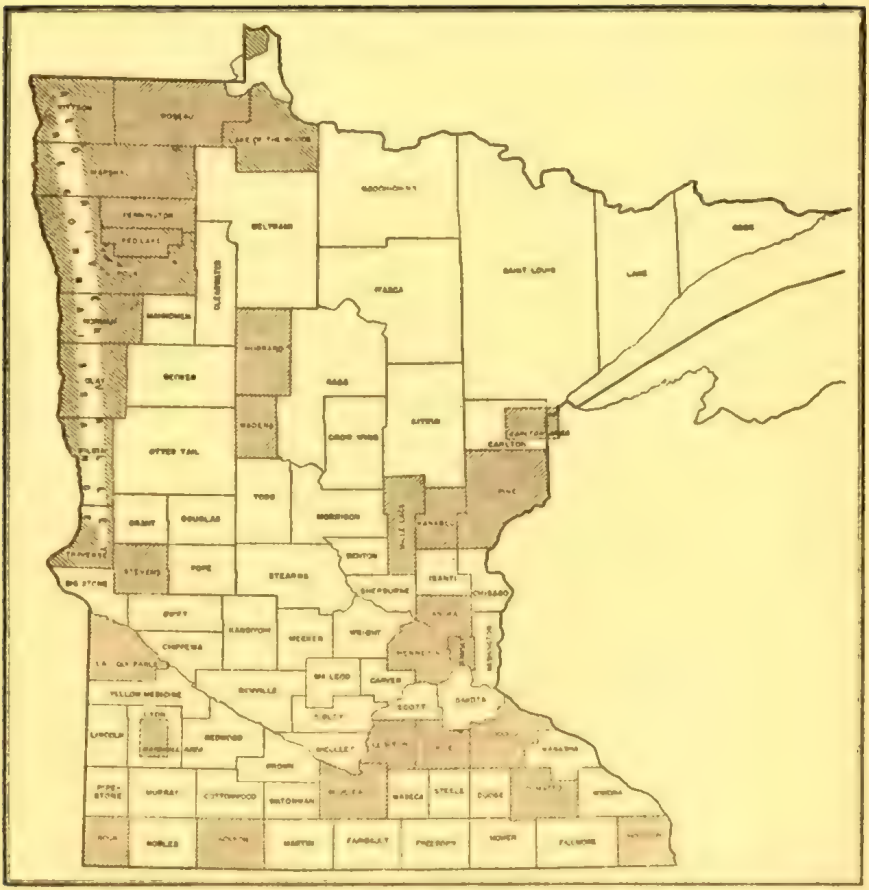

Areas surveyed in Minnesota shown by shading. Detailed and semidetailed surveys shown by northeast-southwest hatching; reconnaissance surveys shown by northwest-southeast hatching.

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TABLE 4.—*Characteristics of the soil series in Le Sueur County, Minn.*[1]

Series	Native vegetation	Parent material	Dominant relief	Drainage		Surface soil (A horizon)				Subsoil (B horizon)			
				Surface runoff	Internal	Color[2]	Texture	Consistence	Structure	Color[2]	Texture	Consistence	Structure
SOILS OF THE GLACIAL UPLAND													
Burnsville	Forest	Calcareous till	Undulating to hilly	Medium to rapid.	Medium	Light brown or brownish gray.	Sandy loam	Loose	Crumb	Light brownish gray to light yellowish brown.	Sandy loam	Loose	Single grain.
Clarion	Grass	do	Undulating to rolling	Medium	do	Dark brownish black or black.	Silt loam	Friable	Granular	Dark yellowish brown	Silt loam to silty clay loam.	Compact	Subangular blocky.
Glencoe	do	do	Nearly level (depressional) to gently sloping.	do	Very slow	Black to brownish black	do	Friable, sticky when wet.	do	Medium to light olive gray	Silty clay	do	Cloddy.
Hayden	Forest	do	Undulating to hilly	Medium to rapid.	Medium	Light brownish gray	Loam to silt loam	Friable	Platy	Moderate yellowish brown	Silty clay loam	do	Blocky.
Lakeville	Grass	do	do	do	Rapid	Dark brownish black or black.	Loam to fine sandy loam.	Friable to loose	Crumb	Dark grayish brown	Sandy loam	Loose	Single grain.
Lester	Grass and forest.	do	do	Medium	Medium	Brownish gray to brownish black.	Silt loam	Friable	Slightly granular.	Light brownish gray to dark yellowish brown.	Silty clay loam	Compact, hard, sticky when wet.	Blocky.
Le Sueur	Grass	do	Nearly level to undulating.	Medium to slow.	Slow	Brownish black	Silty clay loam	Friable, sticky when wet.	Granular	Moderate brown to strong brown.	Silty clay loam to silty clay.	Compact, sticky when wet.	Subangular blocky.
Storden	do	do	Hilly	Rapid	Medium	Brownish gray	Silt loam	Friable	do	Light yellowish to moderate grayish brown.	Silt loam	Friable	Granular to subangular blocky.
Terril	Grass and forest.	Fine-textured colluvium over calcareous till.	Gently sloping to sloping.	Medium	do	Dusky brown	do	do	do	Weak brown to yellowish brown.	do	do	Subangular blocky.
Webster	Grass	Calcareous till	Nearly level to undulating.	Medium to slow.	Slow	Grayish black to very dark gray.	Silty clay loam	Sticky when wet	do	Mottled medium gray with strong yellowish brown.	Clay loam to sandy clay.	Compact, sticky when wet.	Do.
SOILS OF THE TERRACES													
Copas	Grass and forest.	Sandy loam over limestone or sandstone.	Nearly level to gently undulating.	Medium	Rapid	Brownish black	Loam	Friable	Granular	Dark reddish brown	Loam	Friable	Subangular blocky.
Estherville	Grass	Sandy loam over limy gravel.	do	do	do	do	Sandy loam	do	do	Dark brown	Sandy loam	do	Do.
Hubbard	do	do	Nearly level to moderately steep.	Medium to rapid.	do	Dusky brown to brownish black.	Fine sandy loam	Loose	Single grain	Moderate brown to dark brown.	do	Loose	Single grain.
Kasota	do	Moderately fine textured material over limy gravel.	Nearly level to very gently undulating.	Medium	Medium	Brownish black to black	Silt loam	Friable, mellow	Granular	Dark yellowish brown to brownish gray.	Silty clay loam	Hard, sticky when wet	Subangular blocky.
Wadena	do	do	Nearly level to rolling	do	do	Brownish black	Loam	Friable	do	Light yellowish brown	Loam	Friable	Do.
SOILS OF THE ALLUVIAL BOTTOM LANDS													
Dorchester	Forest	Recent alluvium	Nearly level	Slow	Slow	Light brownish gray	Silt loam (some variable).	Mellow		Light brownish gray	Silt loam (some variable).	Friable	

[1] Soils of the depressions, mapped in one unit as Peat and muck, are not classified by soil series.

[2] Colors according to: RICE, T. D., NICKERSON, DOROTHY, O'NEAL, A. M., and THORP, JAMES. PRELIMINARY COLOR STANDARDS AND COLOR NAMES FOR SOILS. U. S. Dept. Agr. Misc. Pub. 425, 12 pp., illus. 1941.

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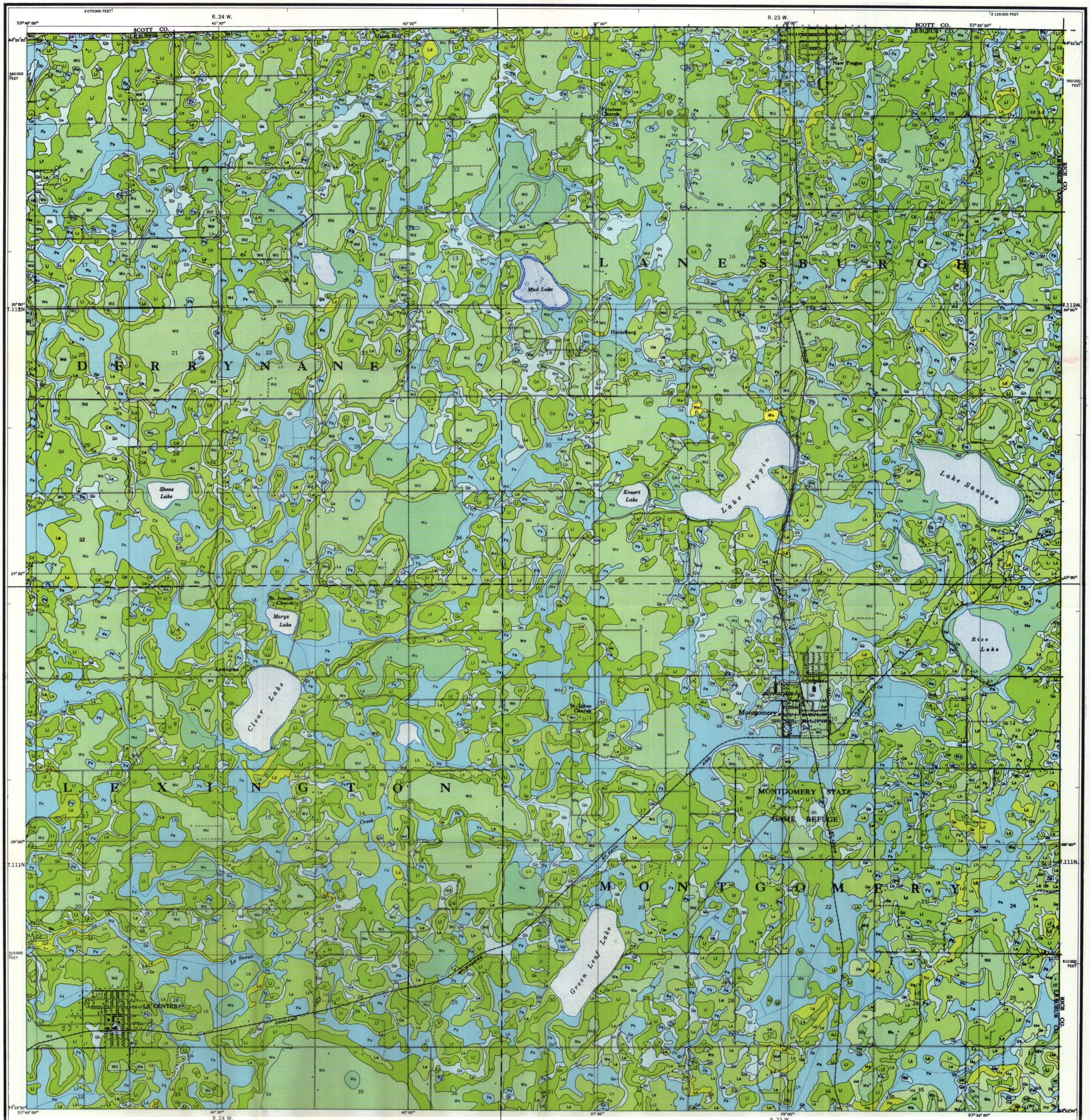
U. S. DEPARTMENT OF AGRICULTURE

SOIL MAP
LE SUEUR COUNTY - MINNESOTA
NORTHEASTERN SHEET

UNIVERSITY OF MINNESOTA
AGRICULTURAL EXPERIMENT STATION



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W. H. Allaway, Chief Analyst, Soil Uses and Productivity
Correlation and inspection by I. J. Nygard,
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Soils surveyed 1943 by Olaf C. Soine, University of Minnesota.

For alphabetical legend and sheet diagram see southwestern sheet.
For color grouping and conventional signs see northwestern sheet.

Map constructed by Cartographic Section, Division of Soil Survey, BPISAE,
from aerial photographs by photogrammetric methods.
H. W. Whitlock, Engineer, In Charge.
Polyconic projection, 1927 North American datum.
Horizontal control by U. S. C. and G. S.
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SOIL MAP
LE SUEUR COUNTY - MINNESOTA
NORTHWESTERN SHEET

UNIVERSITY OF MINNESOTA
AGRICULTURAL EXPERIMENT STATION

COLOR GROUPING

WELL-DRAINED DARK-COLORED SOILS OF THE UPLANDS ON GENTLE SLOPES
- Clarion silt loam, eroded undulating phase
- Clarion silt loam, undulating phase
- Lester silt loam, eroded undulating phase
- Lester silt loam, undulating phase
- Terril silt loam, gently sloping phase

IMPERFECTLY DRAINED DARK-COLORED SOILS
- Le Sueur silty clay loam, nearly level phase
- Webster and LeSueur silty clay loams, nearly level phases
- Webster and LeSueur silty clay loams, undulating phases

POORLY DRAINED DARK-COLORED SOILS
- Glencoe and Webster silty clay loams
- Glencoe silt loam

WELL-DRAINED DARK-COLORED SOILS OF THE UPLANDS ON MODERATE SLOPES
- Clarion silt loam, eroded rolling phase
- Clarion silt loam, rolling phase
- Lester silt loam, eroded rolling phase
- Lester silt loam, rolling phase
- Lester silt loam, severely eroded rolling phase
- Terril silt loam, sloping phase

WELL-DRAINED LIGHT-COLORED SILT LOAMS AND LOAMS ON GENTLE SLOPES
- Hayden silt loam and loam, eroded undulating phases
- Hayden silt loam and loam, undulating phases

WELL-DRAINED LIGHT-COLORED SILT LOAMS AND LOAMS ON MODERATE SLOPES
- Hayden silt loam and loam, rolling phases
- Hayden silt loam and loam, severely eroded rolling phases

WELL-DRAINED DARK-COLORED SOILS OF TERRACES ON GENTLE TO MODERATE SLOPES
- Estherville sandy loam
- Hubbard fine sandy loam, eroded rolling phase
- Hubbard fine sandy loam, eroded undulating phase
- Hubbard fine sandy loam, nearly level phase
- Kasota silt loam
- Wadena loam, nearly level phase
- Wadena loam, rolling phase
- Wadena loam, undulating phase

WELL-DRAINED SANDY SOILS ON GENTLE TO MODERATE SLOPES
- Burnsville sandy loam, eroded rolling phase
- Burnsville sandy loam, eroded undulating phase
- Burnsville sandy loam, rolling phase

INTERMINGLED SILT LOAMS AND SANDY LOAMS ON GENTLE TO MODERATE SLOPES
- Lester-Lakeville complex, eroded rolling phases
- Lester-Lakeville complex, undulating and rolling phases

SHALLOW SOILS OVER BEDROCK
- Copas loam, nearly level phase
- Copas loam, undulating phase

HILLY TO STEEP SOILS
- Burnsville sandy loam, hilly phase
- Hayden silt loam and loam, eroded hilly phases
- Hayden silt loam and loam, hilly phases
- Hubbard fine sandy loam, moderately steep phase
- Lester-Lakeville complex, hilly phases
- Lester silt loam, eroded hilly phase
- Lester silt loam, hilly phase
- Storden silt loam, hilly phase

SOILS OF THE FLOOD PLAINS
- Dorchester silt loam
- Mixed alluvium

ORGANIC SOILS
- Peat and muck

MISCELLANEOUS NONARABLE LAND TYPES
- Beach sand
- Gravel pits
- Marsh
- Steep land (Lester and Hayden soil materials)
- Terrace escarpment

CONVENTIONAL SIGNS

CULTURE
(Printed in black)

- City or Village, Roads, Buildings, Wharves, Jetties, Breakwater, Levee, Lighthouse, Fort
- Secondary roads, Trails
- Railroads
- Bridges, Ferry
- Railroad crossings
- Ford, Dam, Sawmill, Windmill
- Boundary lines
- School, Church, Creamery, Cemeteries
- Boundary lines
- Triangulation station, Boundary monument, Oil or Gas wells
- U. S. Township and Section lines, Recovered corners
- Forest fire station, Airway beacon, Oil or Gas tanks
- Transmission line, Oil or Gas pipe line
- Mine or Quarry, Rock outcrop, Made land
- Soil boundaries: Stony, Gravelly, and Cherty areas

RELIEF
(Printed in brown or black)

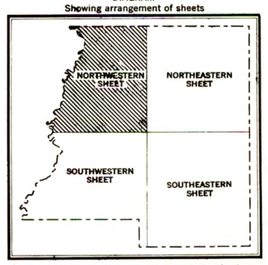
- Contours, Depression contours
- Prominent hills or Mountain peaks
- Sand, Wash, Sand dunes
- Bluff, Escarpment, Mine dumps

DRAINAGE
(Printed in blue)

- Streams, Springs, Wells, Flowing wells
- Lakes, Ponds, Intermittent lakes
- Unsurveyed and Intermittent streams
- Water pipe lines, Canals, Ditches, Flumes
- Swamp, Salt marsh
- Submerged marsh, Tidal flats

The above signs are in current use on the soil map. Variations from this usage appear in some maps of earlier dates.

DIAGRAM
Showing arrangement of sheets



For alphabetical legend see southwestern sheet.

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U. S. DEPARTMENT OF AGRICULTURE

LE SUEUR COUNTY - MINNESOTA

SOUTHEASTERN SHEET

UNIVERSITY OF MINNESOTA
AGRICULTURAL EXPERIMENT STATION

LEXINGTON
CORDOVA
MONTGOMERY
KILLKENNY
ELYSIAN
WATERVILLE

Lake Volsey
Lake Mabel
Lake Dora
German Lake
Big Cannon River
Diamond Lake
Goose Lake
Bosuot Lake
Sabre Lake
Little Cannon River
Jefferson Lake
German Lake
Rice Lake
Sasse Lake
Roemhildts Lake
Steele Lake
Fish Lake
Silver Lake
Round Lake
Lake Francis
Rays Lake
Tetonka Lake
Sakatah Lake
Lake Elysian
Fish Lake
Horseshoe Lake

Doyle
Klikenny
Elysian
Waterville
Greenland
St. Pauls Church
St. Peters Church

R. 24 W.
R. 23 W.
T.111N.
T.110N.
T.109N.
93°45′00″
93°32′30″
42′30″
37′30″
44°22′30″
44°12′30″
2070000 FEET
2120000 FEET
500000 FEET
440000 FEET

LE SUEUR CO.
RICE CO.
WASECA CO.

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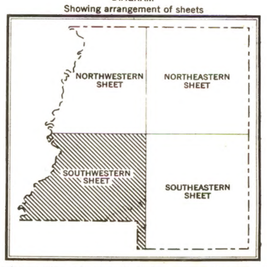
SOIL MAP
LE SUEUR COUNTY - MINNESOTA
SOUTHWESTERN SHEET

UNIVERSITY OF MINNESOTA
AGRICULTURAL EXPERIMENT STATION

DIAGRAM
Showing arrangement of sheets



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LEGEND

Ba Beach sand	Be Burnsville sandy loam, rolling phase	Cd Clarion silt loam, undulating phase	Ea Estherville sandy loam	Ha Hayden silt loam and loam, eroded hilly phases	He Hayden silt loam and loam, severely eroded rolling phases	Hk Hubbard fine sandy loam, moderately steep phase	Lb Lester-Lakeville complex, hilly phases	Lf Lester silt loam, eroded undulating phase	Ll Lester silt loam, undulating phase	Pa Peat and muck	Tb Terril silt loam, gently sloping phase	Wc Wadena loam, undulating phase
Bb Burnsville sandy loam, eroded rolling phase	Ca Clarion silt loam, eroded rolling phase	Ce Copas loam, nearly level phase	Ga Glencoe and Webster silty clay loams	Hb Hayden silt loam and loam, eroded undulating phases	Hf Hayden silt loam and loam, undulating phases	Hl Hubbard fine sandy loam, nearly level phase	Lc Lester-Lakeville complex, undulating and rolling phases	Lg Lester silt loam, hilly phase	Lm Le Sueur silty clay loam, nearly level phase	Sa Steep land (Lester and Hayden soil materials)	Tc Terril silt loam, sloping phase	Wd Webster and Le Sueur silty clay loams, nearly level phases
Bc Burnsville sandy loam, eroded undulating phase	Cb Clarion silt loam, eroded undulating phase	Cf Copas loam, undulating phase	Gb Glencoe silt loam	Hc Hayden silt loam and loam, hilly phases	Hg Hubbard fine sandy loam, eroded rolling phase	Ka Kasota silt loam	Ld Lester silt loam, eroded hilly phase	Lh Lester silt loam, rolling phase	Ma Marsh	Sb Storden silt loam, hilly phase	Wa Wadena loam, nearly level phase	We Webster and Le Sueur silty clay loams, undulating phases
Bd Burnsville sandy loam hilly phase	Cc Clarion silt loam, rolling phase	Ds Dorchester silt loam	Gp Gravel pits	Hd Hayden silt loam and loam, rolling phases	Hh Hubbard fine sandy loam, eroded undulating phase	La Lester-Lakeville complex, eroded rolling phases	Le Lester silt loam, eroded rolling phase	Lk Lester silt loam, severely eroded rolling phase	Mb Mixed alluvium	Ts Terrace escarpment	Wb Wadena loam, rolling phase	